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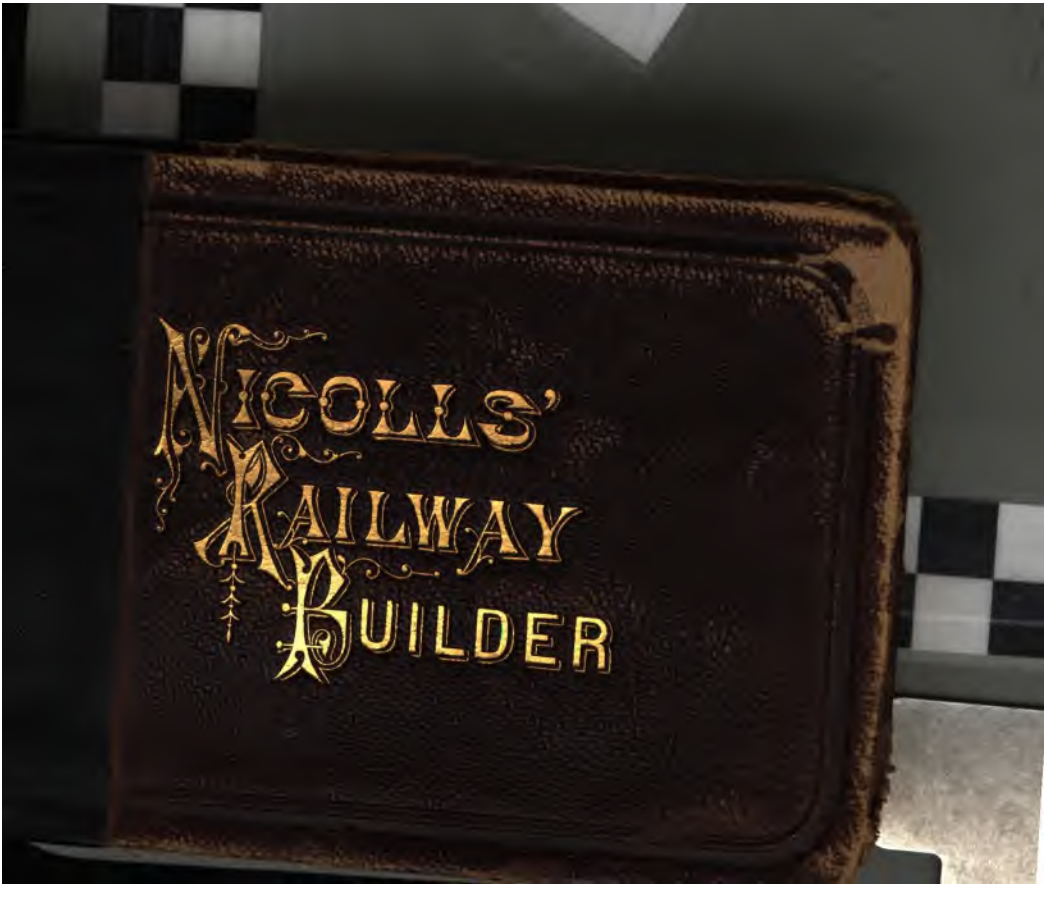
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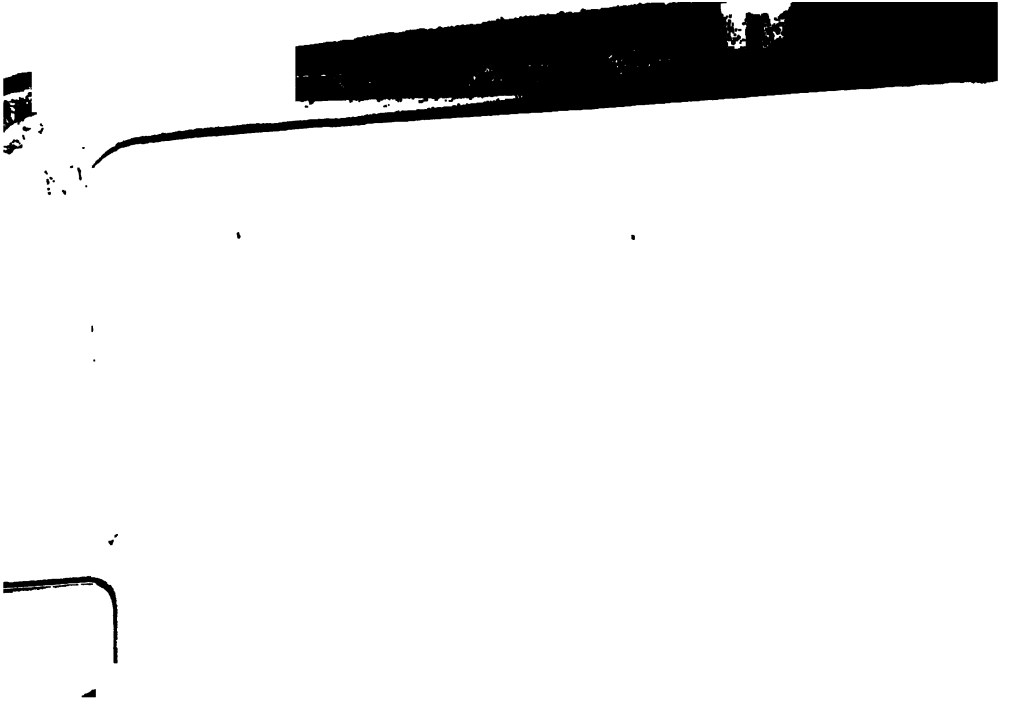

RAILWAY BUILDER.

A HANDBOOK

FOR

ESTIMATING THE PROBABLE COST OF AMERICAN RAILWAY CONSTRUCTION AND EQUIPMENT.

BY

WILLIAM J. NICOLLS,
CIVIL ENGINEER.

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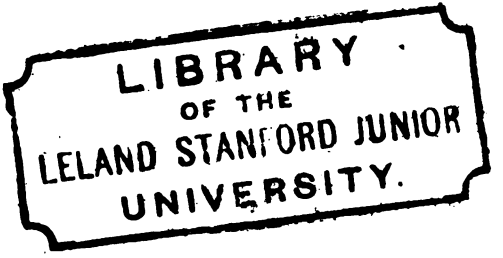

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PREFACE.

In offering this little volume to the railroad world the Author realizes the fact that other books have been published covering the same ground in detail; and that numerous works by Engineers of known ability and reputation are also in existence, which contain an immense fund of general information and most of the tables necessary for calculation. But they are either in a condensed form, or clothed in formulas and symbols totally unknown to the average railroad man. During a professional career of nine years the Author has had a varied experience, embracing nearly every kind of railway construction, locating, building, and equipping them, and during that period has also been closely identified with

works manufacturing railway plant. From notes collected during this time, often from the expressed opinions of prominent railway men, from information obtained in travelling over nearly every railway in the United States and the Canadas, and from the works before mentioned, this book has been prepared, not for the critical *savant*, but for the daily use of practical railroad men, those not conversant with Engineering formulas or manufacturers' processes, to enable them to familiarize themselves with the subject and to assist them in estimating the probable cost of constructing and equipping an American railway. The writer acknowledges himself indebted to Trautwine, Haswell, Jervis, Forney, Barry, Gillespie, Haupt, Knight, and Lorenz.

WM. J. NICOLLS.

NEW YORK, May 4, 1878.

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THE RAILWAY BUILDER.

CHAPTER I.

FIELD OPERATIONS.

BEFORE any idea can be formed regarding the probable cost of a projected line of railway, it is necessary to have as complete a map as possible of the proposed

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degrees and parts of degrees. Through the centre of this plate passes an upright axis, and on it is fixed a second circular plate, which nearly touches the first plate, and can turn freely around to the right and to the left. This second plate carries a telescope which

the centre of the instrument to the two objects. The cost of one of these instruments, suitable for railroad work, is about $200. THE ENGINEER'S LEVEL consists simply of a telescope suspended in the two arms of a Y, and attached to it is a small spirit level. By means of screws operated by the Leveller, the telescope is made level, and when in this position the Leveller reads from his rod the height of his instrument and by calculations—explained hereafter—determines the different elevations of the country through which the line of survey is passing. This instrument will cost about $150. THE CHAIN is used for measuring the length of the lines which have previously been determined by the Transitman. It is composed of 100 links of wire, steel or iron, each link being one foot in length; at every tenth link is fastened a brass tag, having one, two, three, or four points, corresponding to the number of tens which it makes, counting from the nearest end of the

chain. The middle of the chain, or fiftieth link is marked by a round piece of brass. A good steel chain 100 feet in length is worth from $10 to $15. An outfit for a field party, sufficiently complete for all practical purposes, would be about as follows:—

1.	Engineer's Transit	$200.00
1.	" Level	150.00
1.	" Level Rod	15.00
1.	Steel Chain	15.00
2.	Transit Rods @ $1.00 . . .	2.00
1.	100 ft. tape, $5, 1–50 ft. tape, $3 .	8.00
2.	Short-handled Axes @ $1.50 . .	3.00
1.	Pocket Level	8.00
1.	Slope "	6.00
	Incidentals	10.00
		$417.00

In running a preliminary line for a ilroad, straight lines only are located ı the ground, and where these straight es intersect or join each other, an angle formed, the size of which is exactly denined by the transit, so named, because telescope of the instrument is capable

of making a complete revolution on its axis, which is not the case with the theodolite. In running a line with the transit, we first ascertain at what point the survey is to commence, then we designate that point as station O. Now set the transit exactly over this point by means of the "plumb bob" and line which is suspended from it, and level it up. Direct the telescope to the rod, which is held by the "front rodman" at the point determined upon by the "Chief." Sight to the lowest visible point of the rod, clamp the instrument, and when the needle of the compass comes to a rest, read the course or bearing of the line which connects these two points. The bearing is noted by reading between what letters on the compass the end of the needle comes, and to what number, naming or writing down FIRSTLY, the letter N. or S. (North or South), which is at the 0° point nearest to the end of the needle from which you are reading. SECONDLY, the number of degrees to

which it points; and THIRDLY, the letters E. or W. (East or West), of the 90° point which is nearest to the same end of the needle.

After this course is carefully noted in the field-book (suppose it to be N. 45° E.), direct the chainmen to measure the distance from the transit point to the point at which the Front Rodman is stationed, the axman driving a stake every hundred feet (1 chain), and exactly in the line given him by the Transit-man with his instrument, after which take a second sight on the front rod to see that the instrument has not been moved in setting the stakes, and also take a second reading of the compass to avoid any error. The Transitman, after directing his Back Rodman to occupy the position at station will then move up the instrument to point previously established by the ıt Rodman, where he will set up the it, as before. The distance from sta-) to this point has now been ascer- by the Chainmen, and a stake has

:t, or 8 chains, then the ...
: at station 8. The Transitman note
his distance in his field-book, and afte
djusting his instrument so that the VER
NIER plate indicates 0°, the telescope i
reversed, and he takes a "back sight" o
the Back Rodman who is holding his ro
on the head of a tack which is driven i
the stake marked O. After clamping th
instrument the telescope is then reverse
and directed to the Front Rodman, w
has again taken up a position in a
vance which is indicated to him by
Chief as the point to which the line i
be run. At this point there will be
angle, read it on the VERNIER PLATE
also note the new reading given by
needle, taking care to observe wh
the change of direction is to the l
the right. Suppose this angle

to proceed as before, and so continue. The field-book will then look as follows:

TRANSIT BOOK.

Station.	Distance	Angle.	Course.	Remarks.
10				
9				
8⊙	——	15° 30′ R.	N.60° 30′ E.	Plug
7				
6				
5	800′			
4				
3				
2				
1				
0⊙			N. 45° E.	

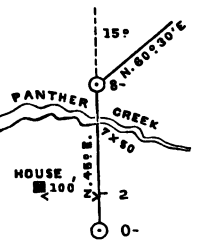

Fig. 1.

0. On plug intersection of centre line of Madison and Elm Streets.

And so proceed, noting carefully the topography of the country through which the line is running—in the field-book—and marking the distances to any prominent object from the line, such as a large tree, house, barn, stream or river. The can be done by the Transitman, and noted

his field-book as above, but it is much referable to have an extra man to take ie topography of the country in a sepa- ate book, thus avoiding confusion of igures, and giving the Transitman more ime to devote to his calculations and in- strument. In running a "line of survey" it frequently occurs that obstacles to mea- surement are met which will necessitate a knowledge of triangulation. The simplest forms are noted below :—

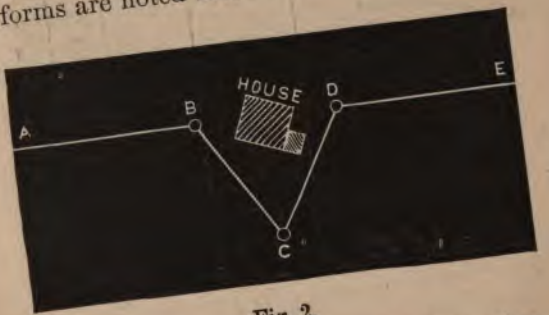

Fig. 2.

1st. *When a tree or house is obstructing the line.* Suppose in figure A B is survey. At B set up the

figure A B is the line of survey. At B set up the [illegible] and taking a back sight on A

with the vernier set at 0°, reverse the telescope and turn aside from the line at an angle of 60°, and measure any convenient distance B C. Move to C and turn 60° in the contrary direction, and measure to D the same distance as B C. Then move to D, and turn 60° from C D, prolonged, and D E will be the "line of survey" continued.

2d. *When one end of the line is inaccessible.* Suppose the [illegible]

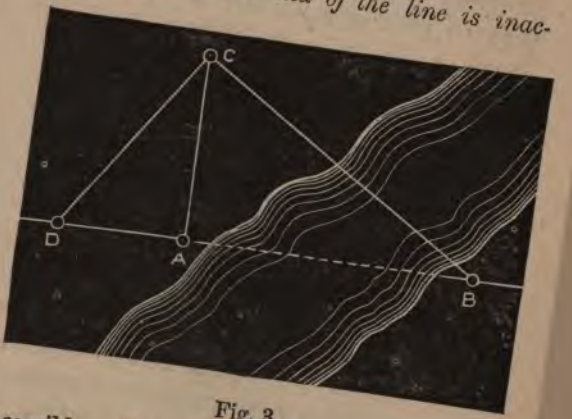

Fig. 3.

the line of survey, and B is inaccessible. At the point A set off A C perpendicular to A B of any convenient length. At C set off a perpendicular to C B, and continue it to a point D in the line of A and B. Measure D A. Then is $A B = \frac{A C^2}{A D}$.

These are the most common triangulations in ordinary practice, but other cases may occur which will require more complicated figures. A study of the subject is then advisable. We have now the line of survey, and want to know the elevations or levels of the country traversed by that line. The Leveller and his Rodman have been following the transit party, as follows: First, setting up the level instrument at some convenient distance about midway between station 0 and station 8, he directs the Rodman to hold his rod on some fixed point, say in this instance, on top of the curbstone, at the corner of Madison and Elm Streets, and then sighting through the telescope, he reads how much his line of sight is above the bottom

of the rod, thus getting the height of the instrument above the curb. Then assuming a datum line, say of 100.00, he adds this reading, which is, say 8.5 feet, to the datum, and calls the height of instrument 108.50 feet. He now proceeds to take a reading at each station, 0, 1, 2, 3, 4, etc., up to station 8, and notes down each reading in his book, as follows:—

LEVEL BOOK.

Station	Rod.	Instr't	Elev.	Remarks.
B. M.	6.50	108.50	100.0	On curb cor. Madison
0	13.3		95.2	and Elm Streets.
1	6.2		102.3	
2	8.9		99.6	
3	9.7		98.8	
4	5.3		103.2	
5	4.2		104.3	
6	2.6		105.9	
7	7.1		101.4	
+50	15.00		93.5	Surface water, Pan-
8	3.8		104.7	ther Creek.

and subtracting these readings from the height of instrument gives the elevation

of each point or station. When it is necessary to move the level, the Rodman drives a peg into the ground, and gives a rod on it which the leveller sights to, and after reading it very carefully moves the instrument ahead, sets it up again, takes a sight at the rod again, and *adds* this reading to his last elevation (*i. e.* the elevation of the turning peg); this gives him a new height of instrument, and he proceeds as before.

The preliminary line finished, the next proceeding is to locate it. Curves must be put in at every angle, or often the whole direction of the line changed. Without stopping to explain the compound curve, reversed curve, or any of the intricacies of location, it is thought advisable simply to give a rule for inserting a curve at any of the angles of intersection. Suppose it is required to find the point A or D at which to commence a curve of a given radius.

RULE.—Subtract half the angle A B D

from 90°, the remainder will be the angle B C A or B C D. From a table of natural tangents, take the tangent of B C A, and multiply it by the given radius, the product will be B A or B D. Now having calculated the apex distance, and at what point the curve is to commence, we measure back from the point of intersection

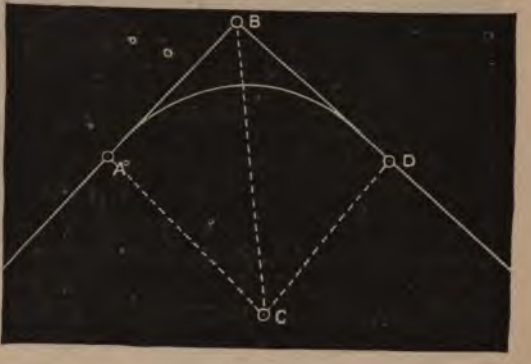

Fig. 4.

that distance, and establish the point of curve (P C) on the ground. Then to locate it, the transit is set up at the point of

of each point or station. When it is necessary to move the level, the Rodman drives a peg into the ground, and gives a rod on it which the Leveller sights to, and after reading it very carefully moves the instrument ahead, sets it up again, takes a sight at the rod again, and *adds* this reading to his last elevation (*i. e.* the elevation of the turning peg); this gives him a new height of instrument, and he proceeds as before.

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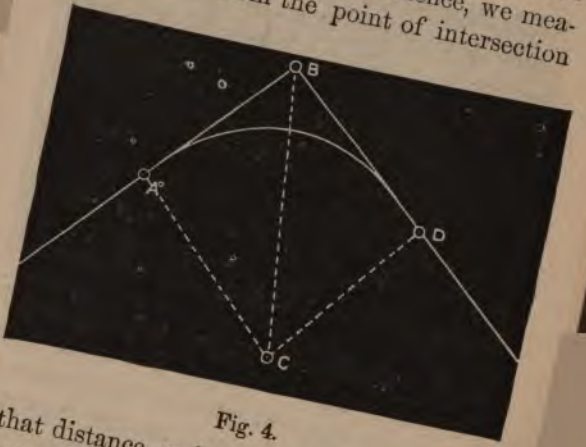


Fig. 4.

that distance, and establish the point of curve (P C) on the ground. Then to locate it, the transit is set up at the point of

rve, and a deflection is made for every 0 feet, equal to ½ of the degree of curve. hat is, suppose it is required to locate a ° curve, we first deflect 3°, then for the ıext station of 100 feet 3° more, and so proceed to the end of the curve, then in

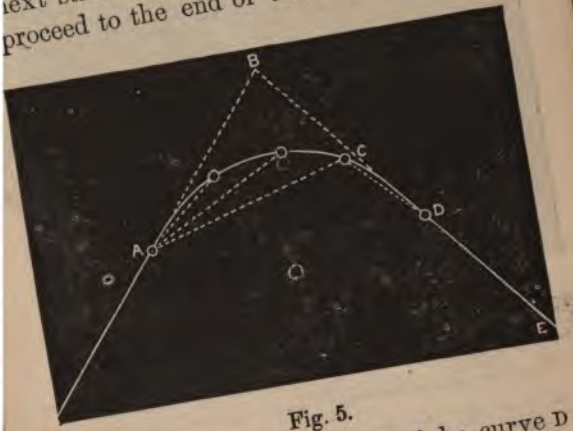


Fig. 5.

order to pass from the end of the curve D on to the tangent D E, place the instrument at D, and sighting back to C, lay off the tangential angle C D B, then B D continued towards E will be the required tangent.

With this brief introduction regarding field operations, a subject has been considered, which in itself would require a volume to be complete. The writer presents only the simplest operations of any Engineer's experience in the field and "on survey," sufficient, however, for the wants of the *un*scientific man, for whom this work is chiefly intended.

RAILWAY CURVES.

Degree.	Radius.	Vers. sine.
1 deg.	5,730 feet.	1–8 inch.
2 "	2,865 "	3–16 "
3 "	1,910 "	5–16 "
4 "	1,432 "	7–16 "
5 "	1,146 "	1–2 "
6 "	955 "	5–8 "
7 "	819 "	3–4 "
8 "	716 "	13–16 "
9 "	637 "	15–16 "
10 "	573 "	1 1–16 "
11 "	521 "	1 1–8 "
12 "	478 "	1 1–4 "
13 "	441 "	1 3–8 "
14 "	410 "	1 7–16 "
15 "	383 "	1 9–16 "
16 "	359 "	1 11–16 "
17 "	338 "	1 3–4 "
18 "	319 "	1 7–8 "
19 "	302 "	2 "
20 "	287 "	2 1–16 "

The radius of a 1 degree curve equals about $1\frac{1}{2}$ miles. That of any other degree is found by dividing $1\frac{1}{2}$ miles or 5730 feet, by the number of degrees.

EXAMPLE. — Radius 6° curve = 5730 ÷ 6 = 955 feet.

Curvature of the earth is equal to 8 inches per statute mile.

CHAPTER II.

PRELIMINARY SURVEYS.

THE first object for consideration in locating a line for a railway is to ascertain, as far as practicable, the probable amount of traffic to be provided for, together with the nature of the same, and the direction in which it will probably run; also what rate of speed is proposed for the rolling stock: if high, the superstructure must be made stronger and heavier, grades must be made easier, and curves lighter, than if a low rate of speed is contemplated. With this information in view, and carefully considered, the Engineer can proceed to locate the line with more intelligence, and a greater degree of success than usually attends the average "locations" of the present day. The first, or PRELIMINARY SURVEY, is made

with the view of examining the country through which the contemplated railroad is to pass, and by trial lines, and notes collected from actual survey, to arrive at some probable route, and an approximate estimate of its cost. The points from which the railroad is to start and terminate, are given, and the Engineer's duty consists in LOCATING THE LINE which is to connect them, and to prepare a plan, profile, and estimate of the cost of building a railroad on that line.

This duty involves a great amount of labor, trouble, and annoyance. A determined, resolute Engineer will make his location, entirely relying on his own judgment and skill, making such changes only as he himself thinks right, ignoring completely scheming directors and others having for their only object the filling of their pockets at the expense of the enterprise. It is too often the case that the locating Engineer is besieged by the men along the line, very often directors of the

company, and obliged to subject his own better judgment as to what route would be best, to the wishes of an interested party, who is too powerful with the company for the Engineer to differ from. Again a wealthy individual along the line proposes to subscribe liberally to the stock "if the line goes here or there," or any place except the right place, where the Engineer has fixed it. And so very often, owing to such influences, the road is improperly located; large expenses are incurred to correct it; profits melt away on the poorly located line, and the road is not only a failure, but the Engineer's ability is questioned much to his injury. It is surprising how necessary a thing it is for a man to "serve his time" to every profession except Engineering. The moment a railroad is projected, every man along the line becomes a good locating Engineer, and viewing with disgust the line as proposed by the Engineer who has devoted a dozen or more years of his life

in the practice of his profession, points out what route *he* would take. Still, as before suggested, an Engineer should use his own judgment, ignoring all counter suggestions by unskilful men, acting in perfect fairness to all parties, and with strict fidelity to the company employing him. Much more could be said regarding location, but the writer is necessarily restricted to a simple hand-book, and the temptation to write further cannot be indulged in. Several very valuable works are in print, treating the subject in every detail. A little manual on "Railway Property," by John B. Jervis, C. E., deals with the subject almost in the very thoughts of the writer. If the country through which the line is intended to run, is well adapted to the construction, a preliminary survey can be arrived at, and an estimate made in a comparatively short time, regulated, of course, by the length of the road and the difficulties to be encountered. A fair estimate of the

cost of a preliminary survey and estimate, is $35.00 per mile, including everything (although much higher charges are made by Engineers of a speculative turn of mind), plan, profile, and estimate. When this has been made and the feasibility of building the road is decided, negotiations should be commenced for the "RIGHT OF WAY," which will determine, in a great measure, whether the road can be built. When it is known that the road is really to be built, and through certain properties, the value of those "estates" immediately assumes gigantic proportions; persons who before the survey was made were willing to give their lands away wholesale to the railroad company, now become strangely reluctant even to sell the smallest morsel. The frailty of human nature is sadly exemplified in these property owners, and a barrier, sometimes insurmountable, is placed in the company's way. In this dilemma, there are two alternatives: one is to revise the line,

xorbitant
w and courts; the latter
aled to, but only as a last resort, it
g exceedingly difficult to find twelve
ymen who are not more or less in close
npathy with the individual, and
ainst the company. An amicable adjust-
ent should be made, if possible, between
he parties by an uninterested arbitrator
aken from a different section of country.
This will be found the easiest and the
simplest form of adjustment. Should the
property owners be willing to concede
sufficient ground for the right of way, a
conditional or preliminary agreement is
entered into, in the following form:—

Grant of Right of Way and Release of Damages.

——— ———, *To the* ——— *Railroad Co.*

Know all men by these presents, That whereas "THE ——— ——— RAILROAD COMPANY," a corporation formed under

and in pursuance of the laws of the State of ——, for the purpose of locating and constructing a Railroad from —— to —— in said State, have located or are about to locate their Railroad through, over, or upon the lands, premises, and property of the undersigned —— in —— County in the said State, and for the said purpose are desirous of obtaining the Right of Way in, through, and upon the said lands and premises. Now, therefore, the said —— for and in consideration of the location of the said Railroad through and upon his lands, and of the advantages which may accrue to him therefrom, and also of the sum of one dollar in hand paid, the receipt whereof is hereby acknowledged, —— doth hereby, for himself, his heirs, executors or administrators, give, grant, sell and convey unto the said "THE —— —— RAILROAD COMPANY," their successors and assigns, for the uses and purposes of their Railroad and the construction of works con-

nected therewith, the absolute Right of Way through, over and upon his said lands the whole distance of the said Railroad through and over the same, with the unrestricted right and privilege to enter upon, locate and construct their railroad on, over and through his lands as aforesaid, to such extent as may be necessary for the location, construction, opening and use of said Railroad, not exceeding —— feet in width on and of the said lands, with such additional width, however, as may be required at deep cuttings and embankments, one-half thereof on each side of the *Centre Line* of the main track of said Railroad as laid down and established by the said Company on their located route, and the full liberty to make, maintain and use the said Railroad over, through and upon the said lands, with the usual Road-bed, Slopes, Berms, Ditches, Spoil-banks and Borrow-pits; and also the right to take and use any water from springs or streams

upon the said lands, and to conduct and carry water by pipe or otherwise over, through or under the same, and to establish Water-stations thereon.

And the said —— further covenants and agrees with the said Railroad Company, their successors and assigns, that on the said Railroad from —— City to —— City being completed and placed in running order, he, his heirs, executors or administrators, at the proper cost and request of the said Railroad Company, will grant and convey the lands and premises hereinbefore described, and the rights and privileges appurtenant thereto, to the said Railroad Company, their successors and assigns, so long as the same shall be required for the uses of the said Railroad by the said Company, its successors and assigns, —— and in said Instrument of Conveyance to discharge and forever release the said "THE —— —— RAILROAD COMPANY," their successors and assigns, from any further payments for,

the said lands
for any and all damag
crued or which may
reason of the locati
perating and using c
oad through, over, and
aforesaid. Provided,
construction of the sai
begun within twelve
said Road shall be i
two years from this d

In witness whereo
hereunto set his han
the —— day of ——

table shows how much
ired, per mile and hundred
nt widths for *Right of Way*

s required per mile, and per
or different widths (Traut-

Acres per 100 feet.	Width in feet.	Acres per mile.	Amount per 100 feet.
.046	31	3.76	.071
.048	32	3.88	.073
.051	33	4.00	.076
.053	34	4.12	.078
.055	35	4.24	.080
.057	36	4.36	.083
.057	37	4.48	.085
.060	38	4.61	.087
.062	39	4.73	.090
.064	40	4.85	.092
.067	41	4.97	.094
.069	" $\frac{1}{4}$	5.	.094

of the ground, of course,
different localities.
ocation of the railroad has

taken from a contract made by the Pennsylvania Railroad.

Form of Contract and Proposal.

—— —— Railroad.

CONTRACT.

Articles of Agreement made and concluded this —— day of —— in the year of our Lord one thousand eight hundred and —— by and between —— of the first part, and the —— railroad company, of the second part, *witnesseth*, that for and in consideration of the payments and covenants hereinafter mentioned, to be made and performed by the said Railroad Company, the said party of the first part doth hereby covenant and agree to construct and finish, in the most substantial and workman-like manner, to the satisfaction and acceptance of the Engineer of said Company, all the graduation, masonry, and such other work as may be required on Section ——, numbered —— of said road: the said work to be finished

as described in the following SPECIFICATIONS, and agreeably to the directions, from time to time, of the said Engineer or his assistants, on or before the —— day of —— in the year one thousand eight hundred and ——.

SPECIFICATIONS.

1. *Graduation.*—Under this head will be included all excavations and embankments required for the formation of the road-bed; cutting all ditches or drains about or contiguous to the road, the foundation of culverts, and bridges or walls; the excavations and embankments necessary for reconstructing turnpikes or common roads, in cases where they are destroyed or interfered with in the formation of the road; and all other excavations or embankments connected with or incident to the construction of said rail-road.

2. All cuttings shall be measured in the excavations, and estimated by the

cubic yard, under the following heads, viz.: *earth*, *loose rock*, *solid rock*, *tunnel excavation*, *embankment*.

Earth will include clay, sand, loam, gravel, and all other earthy matter, or earth containing loose stone or boulders, intermixed, which do not exceed in size three cubic feet.

Loose Rock shall include all stone and detached rock lying in separate and contiguous masses, containing not over one cubic yard; also all slate or other rock that can be quarried without blasting, although blasting may be occasionally resorted to.

Solid Rock includes all rock occurring in masses, exceeding one cubic yard, which cannot be removed without blasting.

Tunnel Excavation includes all excavation necessarily taken from the area required to be tunnelled.

3. The road will be graded for a single track, except where otherwise directed

by the Engineer; with side slopes of such inclinations as the Engineer shall, in each case, designate, and in conformity to such breadths, depths, and slopes of cuttings and fillings as may have been, or may hereafter be, determined upon by said Engineer.

4. Earth, gravel, and other materials taken from excavation (except when otherwise directed by the Engineer) shall be deposited in the adjacent embankments, the cost of removing which will be included in the price paid for excavation. It will be understood, therefore, that the excavation price is designed to pay for the excavation, loading, hauling, and dumping in embankments, all material necessarily procured from within the line of the railroad.

Embankment includes all material placed in the embankments of the road-

the excavations of the railway, will be paid for as embankment when hauled to a distance of 1000 feet; in that case it will be paid for as excavation, and also as embankment; when hauled to a distance less than 1000 feet, it will be paid for as excavation only. In procuring materials for embankment from without the line of the road, the place will be designated by the Engineer in charge of the work: and in excavating and removing it, care *must* be taken to injure or disfigure the land as little as possible. The embankments will be formed in layers of such depth (generally one foot), and the materials disposed and distributed in such a manner as the Engineer may direct, the required allowance for settling being added.

Material necessarily wasted from the cuttings shall be used in widening the banks, or be deposited in the vicinity of the road, according to the directions of the Engineer.

5. The ground to be occupied by the excavations and embankments, together with a space of twelve feet beyond the slope-stakes on each side, or ten feet beyond the berme ditch, where one is required, will be cleared of all trees, brush, and other perishable matter. Where the filling does not exceed two and one-half feet, the trees, stumps, and saplings must be grubbed, but under all other portions of the embankment, it will be sufficient that they be cut close to the earth; no separate allowance will be made for grubbing and clearing, but its cost will be included in the price for excavation.

6. Contractors, when desired by the Engineer in charge of the work, will deposit on the side of the road, or at such convenient points as may be designated, any stone or rock that they may excavate; and if, in so doing, they should deposit material required for embankment, the additional cost, if any, of procuring other materials from without the

road, will be allowed. All stone or rock excavated and deposited as above, together with all timber removed from the line of the road, will be considered the property of the railroad company, and the contractors upon the respective sections will be responsible for its safe keeping until removed by said Company, or until his work is finished.

7. The line of the road, or the gradients, may be changed if the Engineer shall consider such changes necessary or expedient; and for any considerable alterations, the injury or advantage to the contractor will be estimated, and such allowance or deduction made in the prices as the Engineer may deem just and equitable; but no claim for an increase in prices of excavation or embankment on the part of the contractor will be allowed or considered unless made in writing before the work on that part of the section, where the alteration has been made, shall have commenced. The Engineer

may, also, on the conditions last named, increase or diminish the length of any section for the purpose of more equalizing or balancing the excavations and embankments.

8. Whenever the route of the railroad is traversed by public or private roads, commodious passing places must be kept open and in safe condition for use; and in passing through farms the contractor must always keep up such necessary fences as will be needed for the preservation of the crops.

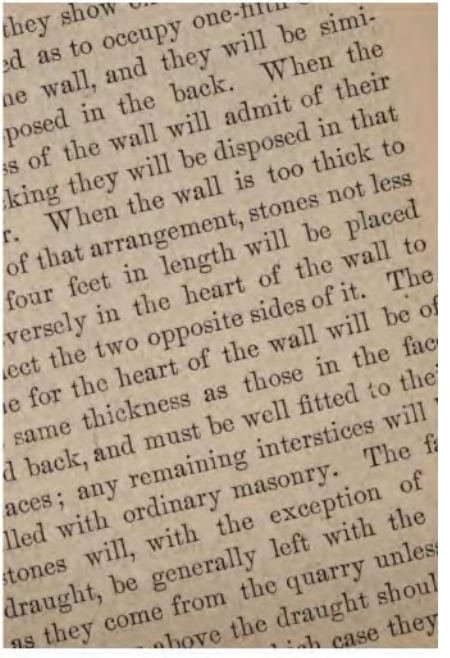
MASONRY.

All masonry will be estimated and paid for by the cubic yard of twenty-seven feet (cubic), and will be included under the following heads, viz.: *culvert masonry*, *bridge masonry*, *vertical and slope wall masonry*.

1. *Culvert Masonry.*—All rectangular culverts will be built dry, with a water way of not less than two and a half by

less than two
sized and well-shaped stone, prop
and bound together by stones, occasionally
extending entirely through the walls.
The upper course to have at least one-
half of the stone headers; and the struc-
tures in no case to be less than twelve
inches wide; no stone in this course to
be less than six inches thick. The cover-
ing to be of sound, strong stone, at least
twelve inches thick, and to lap its whole
width not *less* than ten inches on each
abutment. The thickness of the covering,
stone, and dimensions of the whole walls
to be increased at the discretion of the
Engineer.

2. *Bridge Masonry.*—When rock foundation cannot be had for abutments and piers, the masonry shall be started upon hewn timber, sunk to such a depth as to protect it from decay, and to prevent the possibility of underwashing. The timber platforms will be composed of one or more courses, according to the depth of the water, the height of the masonry, or other circumstances of which the Engineer shall judge and determine. The masonry will be of two qualities, either to be adopted at the *discretion* of the Engineer. FIRST QUALITY shall be rock range work. The stone to be accurately squared, jointed, and bedded, and laid in courses of not less than twelve inches thick, nor exceeding twenty inches in thickness, regularly decreasing from bottom to top of pier or abutment. The stretchers shall, in no case, have less than sixteen inches bed for a twelve inch course, and for all courses above sixteen inches, at least as much bed as face; they shall generally


they show
ed as to occupy one-fifth
ne wall, and they will be simi-
posed in the back. When the
ss of the wall will admit of their
king they will be disposed in that
r. When the wall is too thick to
of that arrangement, stones not less
four feet in length will be placed
versely in the heart of the wall to
ect the two opposite sides of it. The
e for the heart of the wall will be of
same thickness as those in the fac
d back, and must be well fitted to the
aces; any remaining interstices will
lled with ordinary masonry. The fa
tones will, with the exception of
draught, be generally left with the
as they come from the quarry unless
above the draught shoul
case they

be roughly scabbed down to that point. The abutments or piers, and such portions of them as the Engineer may direct, shall be covered with a course of coping not less than ten inches thick, well-dressed, and fastened together with clamps of iron.

The SECOND QUALITY of bridge masonry will be rubble work, laid in irregular courses, and will consist of stone containing generally six cubic feet each, so disposed as to make a firm and compact work; and no stone in the work shall contain less than two cubic feet, except for filling up the interstices between the large blocks in the heart of the wall; at least one-fifth of the face shall be composed of headers, extending full size four feet into the wall, and from the back the same proportion and of the same dimensions, so arranged that a header in the back shall be between two headers in the face. The corner stones shall be neatly

hammer-dressed so as to have horizontal beds and vertical joints.

3. *Vertical and Breast Walls.* — The walls will be good, dry rubble work, the stones to be of such dimensions and laid with such batter as the Engineer may direct.

4. BRICK WORK.—Where bricks are used in piers or abutments of arched or open bridges or tunnels, they shall be made of the best clay, well tempered, moulded, and burnt. The sizes after burning to be nine inches long, four and one-quarter inches wide, and two and one-half inches thick; laid in the best hydraulic mortar, grouted full every three courses, and made with such proportions of cement and sand as the Engineer may direct. The materials for the mortar to be furnished by the contractor. The joints to be of such thickness, and the bond to be of old English or Flemish, or such other character as the Engineer may prescribe, either for the

walls or arches. No bats, cracked, broken, or salmon brick to be used in the work.

The quality of the stone or brick of which the masonry shall be built must be well suited to the kind of structure in which it is used, according to the judgment of the Engineer. All masonry, whether of stone or brick, to be estimated and paid for by the cubic yard of twenty-seven cubic feet. Such portions of the masonry as the Engineer may require to be laid in lime mortar or hydraulic cement, will be so laid.

5. The prices per cubic yard for masonry shall in every case include the furnishing of all materials, excepting lime and cement, the cost of scaffolding, centering, etc., and all the expenses attending the delivery of the materials, and all risks from floods and otherwise.

6. No charge shall be made by the contractor for hindrances or delay from any cause in the progress of any portion of

e work in this contract, but it may entle him to an extension of time allowed or completing the work, sufficient to compensate for the detention; to be determined by the Chief Engineer, provided he shall give the Engineer in charge immediate notice in writing of the cause of the detention.

Nor shall any claim be allowed for extra work, unless the same shall be done in pursuance of an order from the Engineer in charge, and the claim made at the first settlement after the work was executed, unless the Chief Engineer at his discretion should direct the claim or such part as he may deem just and equitable to be allowed.

And the said —— Railroad Company doth promise and agree to pay to the said party of the first part, for completing this contract, as follows, viz.:—

For earth excavation, — cents per cub. yard.
For loose rock excavation, — " " "
For solid rock excavation, — " " "

For embankment,	—	"	"	"
For bridge masonry,				
1st quality,	—	"	"	"
2d quality,	—	"	"	"
For rectangular culverts,	—	"	"	"
For brick arches laid in				
cement,	—	"	"	"
For paving in foundations,	—	"	"	"
For vertical walls or breast				
walls,	—	"	"	"
For timbers in foundations,				
in position,	—	"	per cub. foot.	
For timber worked in				
trestling,	—	"	per 1000 ft. B. M.	
For timber in bridges,	—	"	"	"
For workmanship of timber				
in bridges,	—	"	"	"
For wrought iron, in				
position,	—	"	"	"
For cast iron, in position,	—	"	"	"

Any and all other items at the Engineer's estimate.

On or after the first day of each month during the progress of this work, an estimate shall be made of the relative value of the work done, to be judged of by the Engineer, and upon his certificate of the amount being presented to the Treasurer

the work in this contract, but it may entitle him to an extension of time allowed for completing the work, sufficient to compensate for the detention; to be determined by the Chief Engineer, provided he shall give the Engineer in charge immediate notice in writing of the cause of the detention.

Nor shall any claim be allowed for extra work, unless the same shall be done in pursuance of an order from the Engineer in charge, and the claim made at the first settlement after the work was executed, unless the Chief Engineer at his discretion should direct the claim or such part as he may deem just and equitable to be allowed.

And the said —— Railroad Company doth promise and agree to pay to the said party of the first part, for completing this contract, as follows, viz.:—

For earth excavation, — cents per cub. yard.
For loose rock excavation, — " " "
For solid rock excavation, — " " "

Tunnel excavation,	—	cents per cubic yard.
For embankment,	—	" " "
For bridge masonry,		
1st quality,	—	" " "
2d quality,	—	" " "
For rectangular culverts,	—	" " "
For brick arches laid in cement,	—	" " "
For paving in foundations,	—	" " "
For vertical walls or breast walls,	—	" " "
For timbers in foundations, in position,	—	" per cub. foot.
For timber worked in trestling,	—	" per 1000 ft. B. M.
For timber in bridges,	—	" " "
For workmanship of timber in bridges,	—	" " "
For wrought iron, in position,	—	" " "
For cast iron, in position,	—	" " "

Any and all other items at the Engineer's estimate.

On or after the first day of each month during the progress of this work, an estimate shall be made of the relative value of the work done, to be judged of by the Engineer, and upon his certificate of the amount being presented to the Treasurer

the Railroad Company the amount of
id estimate shall be paid to the party
f the first part, at such time and place
as the said Treasurer may designate; and
when all the work embraced in this con-
tract is completed agreeably to the speci-
fications, and in accordance with the
directions, and to the satisfaction and
acceptance of the Engineer, there shall
be a final estimate made of the *quality*,
character, and *value* of said work, agree-
ably to the terms of this agreement, when
the balance appearing due to the said
party of the first part shall be paid to
—— upon —— giving a release, under
seal of the said Railroad Company, from
all claims or demands whatsoever, growing
in any manner out of this agreement. It
is further covenanted and agreed between
the said parties that the said party of the
first part shall not let or transfer this con-
tract to any person (excepting for the
delivery of materials) without the consent
of the Engineer, but will give personal

attention to the work. It is further agreed that the work embraced in this contract shall be commenced within ——— days from this date and prosecuted with such force as the Engineer shall deem adequate to its completion within the time specified, and if at any time the said party of the first part shall refuse or neglect to prosecute the work with a force sufficient in the opinion of the said Engineer for its completion within the time specified in this agreement, then, and in that case, the Engineer in charge, or such other agent as the Engineer may designate, may proceed to employ such a number of workingmen, laborers, and overseers as may, in the opinion of the said Engineer, be necessary to insure the completion of the work within the time hereinbefore limited, at such wages as he may find it necessary or expedient to give, pay all persons so employed, and charge over the amount so paid to the party of the first part, as for so much

money paid to said party of the first part on this contract; or the said Engineer may, at his discretion, for the failure to prosecute the work with an adequate force, for non-compliance with his directions in regard to the manner of constructing it, or for any other omission or neglect of the requirements of this agreement and specifications on the part of the party of the first part, declare this contract, or any portion or section embraced in it, forfeited, which declaration and forfeiture shall exonerate the said —— Railroad Company from any and all obligations and liabilities arising under this contract, the same as if this agreement had never been made, and the reserved percentage of —— upon any work done by the party of the first part may be retained forever by the said Railroad Company. And it is mutually agreed and distinctly understood that the decision of the Chief Engineer shall be final and conclusive in any dispute which

may arise between the parties to this agreement, relative to or touching the same, and each and every of said parties do hereby waive any right of action, suit or suits, or other remedy in law or otherwise, by virtue of said covenants, so that the decision of said Engineer shall, in the nature of an award, be final and conclusive on the rights and claims of said parties.

IN WITNESS WHEREOF, the President of the —— Railroad Company hath signed the same, and caused the corporate seal of said Company to be attached, and the said —— ha— hereunto set —— hand— and seal— the day and year first above written.

—— ——. [SEAL.]
—— ——. [SEAL.]
—— ——. [SEAL.]
—— ——. [SEAL.]

WITNESS:

—— ——.

—— —— Railroad Proposals.

	$	cts.
Excavation per cubic yard, earth,		
" " " loose rock,		
" " " solid "		
" " " tunnel,		
Embankment per cubic yard,		
Masonry (per yard of 27 cubic feet),		
" of bridges, 1st quality,		
" of bridges, 2d quality,		
" of arches, stone,		
" of arches, brick,		
" of rectangular culverts,		
" of paving in foundations,		
" of vertical or breast walls,		
Timber (per 1000 feet, B. M.)		
" in bridges,		
" in trestles,		
Workmanship (per 1000 feet, B. M.)		
" in bridges,		
" in trestles,		
Timber per cubic foot in foundations,		
Iron per pound, in position,		
Wrought iron per pound, in position,		
Cast " " " "		

The undersigned hereby propose to the —— Railroad Company to do all the work on either or all of the sections to

hich prices are affixed in the schedule, cording to the conditions and specifica- ons contained in the printed form of ntract, a copy of which is annexed; d, on the acceptance of this proposal r all or either of the above sections do — hereby bind —— to enter into and ecute a contract in said form for the ices above named.

— 18——

Proposer's Residence,

Nearest Post-office. Signed,

—— ——.

CHAPTER III.

COST OF EARTHWORK.

THE work required to bring the natural formation of the ground to the grade lines of the proposed railroad is called GRADING, and embraces all the cutting and embankment required. Being by far the most expensive part of the enterprise, close attention must be given to it in every estimate that is made. It is divided into two classes; *excavation* and *embankment*. It is very desirable, as far as practicable, for the Engineer to so arrange his grade lines that all the cuttings will yield sufficient material to form all the embankment; the nearest approach to this happy equality of affairs generally shows the cheapest possible line; but there are a great many reasons why such a course is not practicable; for example

the haul may be too long to bring the material from the cutting to the place of embankment, consuming much time and money; in this case "BORROW PITS" are necessary—that is, material must be borrowed from other points than the excavations of the line to form the banks. And in the case of excavation a "WASTE" is organized, or the material from the excavations instead of being used to form the banks is wasted, *i.e.*, dumped into any convenient hollow or ravine. This borrowing and wasting is a very expensive business, and as little of it should be allowed as possible; a contractor should haul at least 1000 feet before any idea of borrowing is allowed. The steepest or MAXIMUM GRADE of a railroad is to be determined by the rolling load that is to pass over it. On the Phila. and Reading R. R., a train of 170 loaded cars, each car carrying 5 tons of coal, is hauled with comparative ease on a level grade at the rate of 12 miles an hour. Where the trade will

making

and the banks not so

nberland and Pennsylvania R. R.,

re grades of 186 feet to the mile,

some of the recently constructed

w-gauge railroads, the writer has

informed of grades of 4 feet in the

or 211 feet to the mile. Often

at deal of unnecessary expense is i

red in the endeavor to preserve

iform grade, which could be saved

ilding a "surface road" or establish

ne grades by frequent changes, so a

conform to the natural surface of

ground.

In this day of bankrupt railro

would be well to examine more

all these minor economies, which

together, sum up a considerable t

locomotive weighing

gra

5	feet	to the	mile,	1150	tons.
10	"	"		939	"
20	"	"		686	"
30	"	"		536	"
40	"	"		437	"
50	"	"		367	"
60	"	"		315	"
70	"	"		275	"
80	"	"		242	"
90	"	"		216	"
100	"	"		194	"
110	"	"		175	"
120	"	"		159	"
130	"	"		146	"
140	"	"		134	"
150	"	"		123	"
160	"	"		113	"
170	"	"		105	"
180	"	"		98	"

At a speed of 8 to 12 miles per hour.

The grade being established to the best possible advantage, the next step is to provide for "STAKING OUT" THE WORK. This is the work of the "constructing corps." The places to be excavated are marked on the ground by driving stakes every 50 or 25 feet along the entire line, and the number of feet of cutting or em-

bank-cut is marked on them with red chalk or "kehl." The side or slope stakes are then set, which indicate the position of the edge of the slope. For the benefit of young Engineers perusing this work, who are not familiar with staking out work, the writer, digressing from the general plan of this treatise, takes the occasion to introduce a simple rule for "staking out," which he has used frequently during his practice in construction work, as follows: When the natural surface of the ground is level, *Add the cut in feet and decimals, multiplied by the slope, to one-half the road-bed.* Thus, for example, suppose the depth of the cut required to be 20.3 feet, the slope to be $1\frac{1}{2}$ to 1, and the road-bed 13 feet, then, by the rule given above, we have $(20.3 \times 1\frac{1}{2}) + 6.5 = 36.95$ feet, which is the distance from the centre line to the edge of the slope on either side of the line. But suppose that the natural surface of the ... is not level, then assume a point

on the ground (apparently right) find its height above grade with the level, multiply this by the slope, and add one-half the road-bed; see how near this calculation comes to the measured distance from the centre to the assumed point; if not right, a second trial will fix the point. If the natural surface of the ground is very much inclined, stake out the upper side only, and allow the lower side to assume its own shape. The ground, being staked out, is then loosened by picks or ploughs, the latter generally being much cheaper; a single plough with two horses and men will loosen up from 200 to 300 yards of stiff soil per day at about $1\frac{1}{2}$ cents per yard; with the pick, a day's work is about 25 yards, or with labor at 50 per day 4 cents per yard. Light soils will average about one-half the labor, while pure sand requires very little, say $\frac{1}{2}$ cent per yard. After loosening the earth it must be shovelled over into carts or wheelbarrows, and

, one driver can attend to 4
ich at $1.00 per day is 25 cents
. When labor is $1.00 per day,
ense of a horse is about 75 cents,
at of the cart, including harness,
pairs, etc., 25 cents, making the
laily cost per cart $1.00. The ex-
of the horse is the same on Sundays
on rainy days as when at work, and
consideration is included in the 75
ts. Some contractors employ a greater
mber of drivers, who also help to load
e carts, so that the expense is about the
me in either case.

Example.—How many cubic yards of
oam, measured in the cut, can be hauled
by a horse and cart in a day of 10 work-
ing hours (600 minutes), the lead or
length of haul of earth being 1000 feet
(or 10 lengths of 100 feet); and what
will be the expense to the contractor for
hauling per cubic yard, assuming the
total cost of cart, horse, and driver, at
$1.25?

Here

$$\frac{\text{600 minutes}}{\text{4 + 10 lengths of 100 feet}} = \frac{600}{14} = \text{43 loads.}$$

And

$$\frac{\text{43 loads}}{3} = \text{14.3 cubic yards.}$$

And

$$\frac{\text{125 cents}}{\text{14.3 cubic yards}} = \text{8.74 cents per cubic yard.''}$$

After the material is hauled away and dumped into position, it is necessary to have it nicely spread in layers on the bank and levelled off. Still quoting from Trautwine: "A bankman will spread from 50 to 100 yards of either common loam or any of the heavier soils, clays, etc., depending on their dryness. This, at $1.00 per day, is 1 to 2 cents per cubic yard; and we may assume 1½ cents as a fair average for such soils, while 1 cent

pick,	4.00 cts.	per	cu. yd.
carts,	5.00	"	"
0 feet,	8.74	"	"
nto layers,	1.50	"	"
ul in order,	2.00	"	"
ntingencies,	5.00		
to contractor,	23.24	"	"
ractor's profit, 10%,	2.62	"	"
al cost to company,	28.86	"	"

he material is hauled away by men wheelbarrows, the cost will exceed foregoing by about 30 per cent.

A CUBIC YARD OF ROCK IN PLAC ore being blasted, will weigh abo tons, if sandstone or conglomer 50 pounds per cubic foot), or 2 ton ood compact granite, gneiss, limest r marble (168 pounds per cubic fo \$1.00 per day, a fai ROCK

while the cost of loading and hauling away would be about 25 cents per cubic yard, or the total cost to the contractor for loosening, loading, hauling away, and dumping, say with a haul of 1000 feet, would be about 75 cents per cubic yard measured in place. Add to this 10 per cent. for contractor's profit, and we have the ACTUAL COST TO THE COMPANY, at 82.5 cents per cubic yard of solid rock. Loose rock will cost about 55 cents to

$6675. Circumstances, of
ary these figures considerably—they
ased on average figures, taken from
ral estimates of roads already built,
ough a rolling country, but one pre-
ting no engineering difficulties; the
aximum haul is considered 1000 feet in
ength. The rule for calculating the cubic
contents of excavation is contained in the
following PRISMOIDAL FORMULA. "*Add
together the areas of the two parallel ends
of the prismoid, and four times the area of
a section half way and parallel to them;
and multiply the sum by one-sixth of the
length of the prismoid, measured perpen-
dicularly to its two parallel ends.*" In
railroads, the prismoids are generally 100
feet long, it is therefore easier to multiply
the sum of the areas in square feet by 100,
and divide the product by 6.

Quantity of Earths equal to a Ton.

Sand, river, as filled into carts,			21	cubic feet.
Sand, pit	"	"	22	"
Gravel, coarse,	"	"	23	"
Marl,	"	"	28	"
Clay, stiff,	"	"	29	"
Chalk, in lumps,	"	"	29	"
Earth, mould,	"	"	33	"

The whole subject is ably handled by Trautwine, on "Excavation and Embankment." From the same author the following on Tunnel excavation is adapted by the writer. In making tunnels for railroads they should, if possible, be straight, especially when there is but a single track, inasmuch as collisions or other accidents in a tunnel would be particularly disastrous. A tunnel should not be made unless the depth of cutting exceeds 60 feet. Firm rock of moderate hardness, and of a durable nature, is the most favorable material for a tunnel, especially if free from springs and lying in horizontal strata. In soft rock, or

in snales (even if hard and firm at first), or in earth, a lining of hard brick or masonry in cement is necessary. A tunnel should have a grade or inclination in one direction for ease of future drainage and ventilation. No special arrangement is necessary for ventilation, either during construction or after, if the length does not exceed 1000 feet; but beyond that, generally during construction either shafts are made, or air is forced into the tunnel through pipes from its ends. But after the work is finished nothing of the kind generally is necessary.

SHAFTS generally cost from one and a half to three times as much per cubic yard as the main tunnel, owing to the greater difficulty of excavating and removing the material, and getting rid of the water, all of which must be done by hoisting. Their sectional areas commonly vary from about 40 to 100 square feet. In excavating the tunnel itself, a HEADING or passage-way 5 or 8 feet high, and 3 to 12

feet wide is driven and maintained a short distance (10 to 100 feet or more), according to the firmness of the material, in advance of the main work. In rock the heading is just below the top of the tunnel, so that the men can conveniently drill holes in its floor for blasting; but in earth, the heading is driven along the bottom of the tunnel, that being the most convenient for enlarging the aperture to the full tunnel size by undermining the earth and letting it fall. In earth, the top and sides of the heading, as well as the tunnel, must be carefully prevented from caving in before the lining is built, and this is done by means of rows of vertical rough timber, props, and horizontal caps or overhead pieces, between which and the earth rough boards are placed to form temporary supporting sides and ceiling to the excavation. The props and caps are placed first, and the boards are then driven in between them and the earthen sides of the excavation. These are gradually re-

moved as the lining is carried forward. THE LINING, when of brick, is usually from 2 to 3 bricks thick (17 to 26 inches) at bottom, and from $1\frac{1}{2}$ to $2\frac{1}{2}$ bricks thick at the top, and when of rough rubble in cement, about half again as thick. It is important that the bricks or stone should be of excellent hard quality, and laid in good cement. The bricks should be moulded to the shape of the arch. As the lining is finished in short lengths, and before the centres are removed, any cavities or voids between it and the earth should be carefully and compactly filled up. Even in rock if much fissured, or if not of durable character, as common slate, lining is necessary.

THE CROSS SECTION of a single-track railroad tunnel in the clear of everything, and for cars of 11 feet extreme width, should not be less than about 15 feet wide by 18 feet high; nor a double track one less than 27 feet wide by 24 feet high, unless in the last case the material is firm

rock, in which a high arch is not necessary for lining. The roof may then be much flatter, so that a height of 20 feet will answer. With cars of 10 feet extreme width, the width of the tunnel may be reduced to 25 feet; or with cars 9 feet wide, to 23 feet. The rate of DAILY PROGRESS from *each* face of a tunnel varies from 18 inches to 9 feet of length per 24 hours with three relays of workingmen. From 1½ to 3 feet may be taken as an average. If the tunnel is through earth the construction of the lining about makes up for the slower excavation of one in rock. In rock, with labor at $1.00 per day, the cost will usually vary with the nature of the rock from $2.00 to $5.00 per cubic yard for the main tunnel; and from $3.00 to $10.00 for the heading; while shafts will average about 50 per cent more than heading. As the sides and roof of a tunnel are very rough, [illegible] the contractor [illegible]

easured in *the clear*. Allowance should made him for this, or the mode of easurement clearly stated in the specifiations. Before commencing a tunnel rial shafts should be sunk to ascertain he nature of the material. In long ones the greatest care and accuracy are necessary for preserving the line of direction, so that the work from both ends shall meet properly in the centre. The cost of a single track tunnel will range from $30 to $75 per foot of length.

On the Reading R. R., during its construction, three tunnels were cut at the following cost per *lineal foot*:—

Black Rock Tunnel,	near	Manayunk,	$90.
Flat "	"	" Phœnixville,	130.
Port Clinton "			82.

which gives an average cost of $101 per lineal foot. The first two named are double track tunnels, and the latter a single track only. The Flat Rock tunnel is 1932 feet long, worked with 6 shafts, and artificial means were used for

ventilation. During the construction of the Black Rock tunnel, the work progressed at the rate of 100 feet in 52 days, while the Port Clinton tunnel was excavated at the rate of 100 lineal feet in 48 days. The Port Clinton tunnel is arched with brick. It is not improbable that this tunnel will be avoided by removing the earth sufficiently for a through cut or by changing the line of the road. At present the up trains pass through the tunnel, and the down trains run around it on a line recently construced, which crosses a river twice in a comparatively short distance. The distance from the crown of the arch to the surface of the ground over head is about 100 feet. Recently a tunnel on the Pennsylvania R. R. was removed by "taking the roof off" and making a through cut at the point where the tunnel formerly stood. It is well to avoid a tunnel if it can possibly be done: a number of trial lines should be run, and shafts should be sunk, before even deciding upon building one.

CHAPTER IV.

PERMANENT WAY.

AFTER the excavations and embankments have been completed, and before the track is laid, the BALLAST should be put on the grading. It consists of from 8 to 28 inches of loose, hard material, of sand, gravel, or good hard broken stone —furnace slag has been used very successfully on some American railroads— reduced to such a size that any piece will go through a ring of two inches diameter. The quantity required will depend on the nature of the material which forms the cuts and banks, and may vary in depth from 1 to 3 feet. Ballasting is necessary to drain the road-bed properly. If the sills or cross-ties should be laid directly on the grading without any intermediate ballast, which unfortunately is often done

in the hurry to get the road in operation, —they are laid on soft clay, which in wet weather washes away from underneath them; or else on solid rock bottom, say of excavations, of that nature which presents such a rigid base as to destroy the rails. The ballast on a railroad gives the track a certain amount of elasticity, absolutely necessary to carry the train, which passes over it, with any degre of safety. Frequently the cross-ties and iron are laid on the sub-grade temporarily, only laying the iron so that the ballast can be hauled to the place required by construction trains, and so save the expense of carting the material. Such cases are admissible, but when the first construction train passes over the rails safely, the temptation to let a freight, and then a passenger train, over the line also, is very seldom resisted, and much injury results in the form of badly bent iron, occasionally an upset engine, and sometimes loss of human life. Too little atten-

tion is paid to ballasting, excepting upon some of our leading railroads, such as the Pennsylvania Railroad, or N. Y. Central, which make it a prominent feature of construction.

The writer's investigations and experience in travelling, have extended over nearly every State in the Union during the past three years, and in nearly every instance in which the rails, frogs, and switches showed unusual signs of wear, the cause could be traced to dirt, or often, to no ballast. The sand ballast of the south makes a good elastic road-bed. The Wilmington & Weldon R. R., near Wilmington has no other ballast except pure clean sand, and apparently it is sufficient. On the Pennsylvania R. R., the ballast is broken stone, sloping from the sills to the sub-grade, and such attention given to it, that care is even taken to have the edges of the ballast laid with a line! The following TABLE gives the number of cubic yards of ballasting required for

one mile of single track railroad. Slopes of the ballast 1 to 1.

Table of Ballasting.

Depth in inches.	Top width in feet.			
	10.	11.	12.	
12	2152	2347	2543	Cubic yards.
18	3374	3667	3960	" "
24	4694	5085	5474	" "
30	6111	6600	7087	" "
				" "

The cost of breaking stone for ballast, exclusive of the cost of the stone, if done by hand, will be about $700 per mile of single track railroad. The stone can generally be procured from the excavations along the line of the road; if not, the cost will be about $1500 per mile to buy and put in position. The hard slag or refuse, from blast furnaces, makes an excellent ballast, its extreme brittleness renders it easy to reduce to the proper size, and it does not crumble to dust as softer material will do; the water finds its way through it with ease, and as it

never packs closely against the CROSS-TIES, the water will not decay as quickly, the air having free access to the wood.

When railroads were first built in England, the rails were firmly bolted to blocks of granite, which were imbedded in the grading; this gave a durable magnificent road-bed, and one over which an engine could pull a greater load than over our timber cross-ties, but every block of stone under the rail had the same effect on it that an anvil would have to a piece of iron on which the smith is using a sledge; the heavy engines when running at any considerable rate of speed battered down the heads of the rails, particularly at the joints, so badly, that the stone had to be removed and timber put in its place to give an elastic road-bed. STRINGERS placed under the rails, running in the same direction, their entire length, were used, but not successfully; the timber would rot in places, and it was found very expensive and inconvenient in repairing to be

obliged to handle such large timber. THE CROSS-TIES as now used on almost all American railroads, excepting a few Southern roads, which are laid with the longitudinal stringers, consist of timbers laid across the ballast at right angles to the line of the road, and usually measure 9 feet long, 7 inches deep, and 8 inches in width, and are usually trees cut down and roughly hewn on the top and bottom sides. A good hard wood is necessary, to prevent the rails from sinking into it. In England, the double-headed rail is used, that is, the top and bottom of the rail are of the same shape, and it has no flat base like the American rail. This necessitates iron chairs placed on each cross-tie, in order to hold the rail in position. In this country the base of the rail rests directly on the cross-ties, and hard wood is necessary to prevent the crushing of its fibres by the rail. White oak, chestnut, locust, and cedar make good cross-ties; elm can be used if of good quality; whatever timber abounds along

the line of the road, if at all hard wood, can be used to greater advantage than any timber which has to be brought from a distance. The seasoning and preparing of cross-ties for railroads has received great attention from many eminent Engineers, and many attempts have been made to prepare the cross-ties previous to laying, so as to prevent or arrest the natural decay of the wood. Some years ago the cross-ties used on the Phila. and Reading R. R. were notched at the points where the rails crossed them, and their ends dipped in coal tar; by this process it was supposed it would preserve the ends from decay. Since then "BURNETTIZING" has been tried on the same road, a process by which the ties were thoroughly saturated with a solution of zinc. Neither of these gave the desired result, and both have been abandoned. The cost of Burnettizing a cross-tie was 25 cents, equal to one-half of its original cost. SAWED CROSS-TIES are often used, but only on trestle work or bridges, although the

writer knows of cases where sawed ties are laid the entire length of the railroad. The following table gives the NUMBER OF CROSS-TIES required to *one mile* of single track railroad, laid in the following order.

18	inches	from	centre to centre,	3520 ties.
21	"	"	"	3017 "
24	"	"	"	2640 "
27	"	"	"	2348 "
30	"	"	"	2113 "

A fair ESTIMATE FOR CROSS-TIES is from 40 to 50 cents apiece, delivered on the line of the road, or about $1700 per mile of single track road.

The history of the *rail* is identical with the history of trainways. Wooden rails were used at New Castle, in 1602.

In 1716, flat pieces of iron were nailed to the wooden rails.

In 1776, cast-iron rails, with upright flange, were laid on wooden sleepers.

In 1789, Loughborough's cast-iron edge rail, with flanges on the wagon wheels.

In 1793, stone bearings were substituted for wooden sleepers.

Wrought-iron bars two or three inches in thickness, spiked to longitudinal sleepers, were then used in connection with flanged wheels.

Wyatt's cast edge rail, leaving an oval section, was then used in connection with grooved wheels in 1800.

Jessop used this rail in 1789, and added the chair—a block of iron—slotted to receive the ends of adjacent rails. The wheel had a tread of 2½ inches, and a flange to keep it on the rail; the sleepers were of wood.

1803. Woodhouse's hollow rail, with a channel for the rounded edge of the wheel.

1805. The fish-bellied rail at Penrhyn.

1810. A square-bodied cast rail.

1811. Blenkinsop's rock rail.

1816. Gosh and Stephenson's flanged rail, which was a lapping continuous rail.

1817. Hawk's cast-iron face on a wrought-iron base.

1820. Birkenshaw's, of Bedlington, Durham, wrought-iron face on a cast-iron

base; he also invented the rolled rail, the iron, while hot, being passed between grooved rollers of the required pattern. This rail, with many modifications, is now used on the different railroads in this country.

As before stated, some few Southern roads in this country are using the old STRAP RAIL, a flat bar of wrought iron resting in its entire length on wooden stringers, and the writer takes occasion to say that in his opinion very many of our present bankrupt railroads might have used this rail to a decided advantage, where the traffic is light, or at least a more economical rail than the present T-rail could be used. An ANGLE RAIL recently presented to the writer's notice, by Mr. Albert Rice, of Boston, seems a very sensible idea, and in very many instances it could certainly be used to decided advantage, especially on suburban roads or other lines doing a light business. The English DOUBLE-HEADED

RAIL is supposed to possess an advantage over the American rail, from the fact that when one head is worn out it can be reversed, and the wheels can be equally accommodated by the other head. If such were really the case, its superiority would be unquestioned, but in actual practice it appears that, by the time one head is worn out, the other has received such injuries from hammering away in the iron chairs, that notches are found in the rail at such points as to render the surface unfit for the wheel to run on, and also to seriously injure the strength of the rail, and again, in many of the sections of English rails the form of the two heads is not alike, so this idea of reversing the rail does not seem to be of much importance. The STEEL-TOP RAIL, MITRE-JOINT RAIL, COMBINATION RAIL, all possess some merit, but their use has been extremely limited, and the writer deems it unnecessary to go into details respecting them. The BESSEMER STEEL RAIL, made by the

Bessemer process, is now the standard rail, and as long as it can be purchased at its present low price, its advantages over the iron rail seem to admit of no argument. In fact the superiority of steel over iron rails is now no longer disputed; they are not only more durable, but are much stronger for the same amount of material, their comparative strength being in the same proportion as 5 to 3. Steel rails are less fibrous than iron, and consequently less liable to splinter off from use. By actual test, one steel rail has outworn 17 iron rails, with only $\frac{5}{16}$ of an inch worn off the top. Great care is necessary in selecting irons for the Bessemer process; only those containing very little sulphur and phosphorus can be used, the former causing red-shortness, and the latter cold-shortness, or brittleness. At the furnace of the Penna. Steel Works, a very superior iron is made which they themselves use in ma[illegible] steel rails. The [illegible]

magnetic, from Dillsburg, York County, Pa., Staten Island, and New Jersey. In making the steel, a large pear-shaped vessel called a converter is used, suspended on trunnions similar to a gun on its carriage, and provided with hydraulic machinery to move it in a vertical arc, or to turn it nearly upside down, so that the molten liquid can be poured out of its mouth when the process is completed. After heating the converter itself to an intense heat, a charge of iron, about 12,000 pounds, previously melted in an ordinary cupola, and accurately weighed, is run into it by gutters; a blast of air is then forced through the mass, through tuyers at a pressure of about 15 pounds to the square inch. The first action of the blast is the conversion of the silicium into silicic acid, which unites with the oxide of iron formed to produce a slag; the graphic carbon is then transformed into chemically combined carbon, a very high temperature is produced chiefly by the combustion of silicium and iron, and

in about ten minutes time the carbon becomes oxidized by the action of the blast, and the flame which is issuing from the mouth of the converter gives the characteristic bluish-violet color of carbonic oxide. When complete decarbonization has taken place, the flame suddenly drops, when the vessel must be immediately turned down and the blast shut off. Great attention is necessary in this part of the process, for if the iron contained in the converter be subjected to the action of the blast for too long a time, the charge is said to be "overblown," and the steel is found to be very defective, if not entirely worthless. After all the carbon and silicium have been burnt out, malleable wrought iron has been produced, which is subsequently converted into steel, by the addition of a certain percentage of spiegeleisen, which performs a twofold part—removing the surplus oxygen which may have remained, and giving the steel its required

degree of hardness; this addition of speigel to the metal produces a violent action, which soon ceases, and the steel is then poured into a ladle, from which it is subsequently run into cast-iron moulds. A small test-ingot is taken from each charge, and chemically tested. The capacity of a Bessemer plant is from 25 to 30 blows per day. From the moulds the steel ingot is taken to the blooming mill, and the ingots are reheated and rolled into blooms, which are in turn heated again, and then rolled into rails. Great care is necessary in manufacturing steel rails to avoid brittleness, and to insure toughness. When steel rails were first manufactured, there was an uncertainty in the quality of the material which raised quite a prejudice in the minds of many Engineers against their use, but the process of manufacture has now been brought to such a high state of perfection that this doubt no longer exists, and where the traffic of the line will permit they are

generally adopted. The cost of steel rails at the present writing (1878) is about $40 per ton at the mills, or about $3760 per mile of single track railroad.

The first steel rail was made in 1857, by Mushet, at the Ebbow-Vale Iron Company Works, in South Wales. It was rolled from cast blooms of Bessemer steel, and laid down at Derby, England, and remained sixteen years, during which time 250 trains, and at least 250 detached engines and tenders passed over it daily. Taking 312 working days in each year, we have the total of 1,252,000 trains, and 1,252,000 detached engines and tenders, which passed over it from the time it was first laid before it was removed to be worked over. Two steel rails of 21 feet in length were laid on the 2d of May, 1862, at the Chalk Farm Bridge, side by side with two ordinary iron rails. After having outlasted 16 faces of the ordinary rails, the steel ones were taken up and l, and it was found that at the of three years and three months

the surface was evenly worn to the extent of only ¼ of an inch, and to all appearance they were capable of enduring a good deal more work. These two rails, during a period of little more than three years, had been exposed to a traffic of 9,550,000 engines, trucks, and carriages, and 95,577,240 tons, an amount of traffic equal to nearly *ten* times that which destroyed the Great Northern iron rails in three years' time.

In England rails are rolled from 15 to 21 feet long, the latter being the most common size. In this country it is not an uncommon feat to roll a perfect rail 60 feet in length, weighing 60 to 70 pounds to the yard. A rail is generally from 3 to 4½ inches high (usually 4½ inches), and the width from 2¼ to 3 inches at the head, 3 to 5 inches on the flange, and having a web or neck of ½ to 1 inch in thickness. The life of *iron rails* of best quality has been found to be 35,000,000 tons over a double line, or 17,500,000 tons over each single rail, and many from

the best makers stand only 5,500,000 to 15,000,000 tons, or equal to 100,000 trains of 150 tons each, independently of the length of time of the traffic. The wear may be estimated as the $\frac{1}{150000}$th part of the value of the rail each time a train goes over it; and if the value of a mile of iron be taken at $5000, the wear would be 5 cents per train per mile.

A great many American railroads are using a rail of the average section of 60 pounds per yard.

Table giving the Number of Tons of Rails required to Lay One Mile of Single Track Railroad of different Weights of Rails, of Steel or Iron.

Weight of rail p'r yard.	Tons per mile.	Weight of rail p'r yard.	Tons per mile.	Weight of rail p'r yard.	Tons per mile.
8 lbs.	$12\frac{1280}{2240}$	45 lbs.	$70\frac{1600}{2240}$	64 lbs.	$100\frac{1280}{2240}$
12 "	$18\frac{1920}{2240}$	50 "	$78\frac{1280}{2240}$	65 "	$102\frac{320}{2240}$
16 "	$25\frac{320}{2240}$	52 "	$81\frac{1600}{2240}$	67 "	$105\frac{640}{2240}$
25 "	$39\frac{640}{2240}$	56 "	88	68 "	$106\frac{1920}{2240}$
30 "	$47\frac{320}{2240}$	57 "	$89\frac{1280}{2240}$	70 "	110
35 "	55	60 "	$94\frac{960}{2240}$		
40 "	$62\frac{1920}{2240}$	62 "	$97\frac{960}{2240}$		

AN IRON RAIL is made by rolling together a number of separate pieces of iron which when placed in position preparatory to rolling, are called "RAIL PILES." These rail piles are formed in different ways according to the ideas of the manufacturer. The pile is first treated in a furnace to a welding heat, and hammered or rolled into a solid lump or bloom, which is again heated and rolled into the desired shape of rails. An iron rail, however, is fibrous, having fibres or a grain in it like wood, and yielding to the action of the wheels will splinter off fibre by fibre. Steel rails are without this defect, and are homogeneous. But again a very important fact to consider in deciding between iron and steel, is that after an iron rail becomes worn out and no longer fit for railroad service, it is still a marketable article, and can readily be disposed of as old iron, at at least two-thirds of its original cost, but what old steel rails are worth, is at present a comparatively unknown quantity.

By the SIEMENS-MARTIN open hearth process, small proportions of old steel can be used up, but the process is costly and slow, and of doubtful economy. IRON RAILS ARE WORTH about $35 per ton at the mills,* or about $3300 per mile of single track railroad, rail weighing 60 pounds

* *Average Prices per ton of Iron and Steel.*

Rails, net cash, f. o. b. New York, 1847 to 1878.

Year.	Steel.	Iron.	Year.	Steel.	Iron.	Remarks.
1847		$70	1863		$70	
1848		60	1864		153	
1849		50	1865		84	
1850		45	1866		80	
1851		45	1867		80	
1852		45	1868		78	
1853		75	1869	$175	75	
854		80	1870	150	75	
355		60	1871	130	70	
56		60	1872	95	90	
57		65	1873	110	85	
8		50	1874	120	65	
)		50	1875	75	50	
		45	1876	70	45	
		40	1877	60	40	
		36	1878	50	35	
				40		

per yard. OLD IRON RAILS are worth $19 per ton at the mills, or about $1800 per mile of single track road, and thus the additional cost of new iron rails would only be $16 per ton, or $1500 per mile. The usual AVERAGE WEIGHT OF RAILS is 60 pounds per yard, although some roads use 67 and 70 pounds to the yard. It is not always best to buy a heavy rail; very often a lighter rail will do as much service for the amount of traffic, making quite a saving in the cost. A rail will usually wear out first at the ends, owing to the wheels hammering over the open joints, which are caused by the rails contracting and expanding at the different degrees of temperature. Many devices have been invented to overcome THE OPEN JOINT, but for all practical purposes they have not been successful; the joint still exists, and is a constant source of annoyance and expense; the only thing to be done is to make that joint as secure as possible by using good fastenings, and

when laying track to make allowances for the contraction and expansion of the rails.

Table giving the Number of Rails and Joints per Mile of Single Track Railroad, for Rails of different Lengths.

Rails 24′	long	each.	440	complete joints	and rails.
" 25	"	"	422	"	" "
" 26	"	"	406	"	" "
" 27	"	"	391	"	" "
" 28	"	"	377	"	" "
" 30	"	"	352	"	" "

In order to fasten two rails together at their ends, some fastening or other coupling must be used. Time and space will not permit even mention by the writer of the hundreds of devices presented to his notice for effecting this object, very many having claims to originality of design, but very little else. On the many miles of railroad now operating in this country, but very little difference will be observed in the manner of fastening or "FISHING" the rails; and the general tendency appears to be towards the adoption as a

STANDARD JOINT of two iron bars, one on each side of the rails and bolted through. These bars are made in many different shapes and sizes, but generally speaking are much alike, simply two bars or plates ranging from 18 to 24 inches in length, and having holes punched in them for the bolts to go through, these holes corresponding in size and position to the holes in the rails. When the joints happen so that a cross-tie is immediately under it, then it is called a "SUPPORTED JOINT," but when the cross-ties come on each side of the joint, it is called a "SUSPENDED JOINT." The latter is undoubtedly the best, possessing greater elasticity and preserving the life of the rail by relieving the anvil pounding it would receive if too rigidly supported. FISH PLATES are usually quoted by the pound or per joint of two bars. The price per pound is about two cents, and per joint, the price will vary according to the weight and size of the bar. The following table has been

prepared for the different sizes, weights, and present prices per pound and joint for

Plain Fish Bars.

(Original.)

Weight of rail.	Length of plate.	Weight of plates.	Price of plates.	Price of joint.	Joint with bolts.
30 lbs.	16½ in.	6½ lbs.	2 cts.	13 cts.	23 cts.
40 "	22 "	13 "	2 "	26 "	36 "
50 "	22 "	13 "	2 "	26 "	36 "
56 "	23 "	16 "	2 "	32 "	45 "
60 "	23 "	16 "	2 "	32 "	45 "
67 "	24 "	18 "	2 "	36 "	50 "

To connect the fish bars with the rails, 4 BOLTS are used, two in the ends of each ail, these bolts measure ¾ of an inch in hickness, and are of various lengths, ually, however, 4¾ inches long. The ads of the bolts are made square, ob- , or with round-button heads, the lat- eing the most common. The holes in ish plate are made oval to fit an oval- d bolt, and prevent it from turning The nuts are made

hexagonal. Bolts and nuts are usually quoted by the pound; a bolt and nut together will weigh about one pound. The price of Fish bolts and nuts is about 3¼ cents per pound, bolt and nut together.

Table of the Number of Fish Plates and Bolts required for One Mile of Single Track Railroad.

(Original.)

Length of rail.	No of plates.	No. of bolts.	No. of joints.	Price per mile for complete joints.
			Complete.	*Rail 60 lbs.*
24 feet.	880	1760	440	$198.00
25 "	844	1688	422	189.00
26 "	812	1624	406	182.00
27 "	782	1564	391	175.00
28 "	754	1508	377	169.00
30 "	704	1408	352	158.00

The customary lengths of rails are seldom under 30 feet. The cost, therefore, of Fish plates and bolts for one mile of single track railroad, will be about $158, as shown by the preceding tables.

Weight of Hot Pressed Nuts.

BOONTON MAKE.

Size No. to 100 pounds.

	Square.	Hexagon.		Square.	Hexagon.
½ inch,	1100	1250	1 inch,	150	170
⅝ "	550	650	1⅛ "	98	110
¾ "	375	415	1¼ "	70	80
⅞ "	230	155	1½ "	45	55

Weight of Nuts and Bolt Heads in lbs.

Diameter of bolt in inches,	¼	⅜	½	⅝	¾	⅞
Weight of hexagon nut & head	.117	.057	.128	.267	.43	.73
Weight of square nut and head	.021	.069	.164	.320	.55	.88

Diameter of bolt in inches	1	1¼	1½	1¾	2	2½	3
Weight of hexagon nut & head	1.10	2.14	3.78	5.6	8.75	17	28.8
Weight of square nut and head	1.31	2.56	4.42	7.0	10.5	21	36.4

Standard for Screw-threads, Bolt-heads, and Nuts.

Adopted by the Master Car-Builders' Association.

Diameter of bolt.	No. of thr'ds per inch.	Diameter of bolt.	No. of thr'ds per inch.	Diameter of bolt.	No. of thr'ds per inch.	Diameter of bolt.	No. of thr'ds per inch.
¼	20	1	8	2½	4½	4½	2½
5/16	18	1¼	7	2¾	4	4¾	2½
3/8	16	1½	7	2¾	4	5	2
7/16	14	1⅝	6	3	3½	5¼	2½
½	13	1¾	6	3¼	3½	5½	2½
9/16	12	1⅞	5½	3½	3½	5¾	2½
5/8	11	2	5	3¾	3	6	2½
11/16	10	2¼	5	4	3		
¾	9	2½	4½	4¼	2⅞		

The distance between the parallel sides of a bolt-head and nut for a rough bolt shall be equal to one and a half diameter of the bolt, plus one-eighth of an inch.

The thickness of the heads for rough bolts shall be equal to one-half of the distance between their parallel sides.

The thickness of the nut shall be equal to the diameter of the bolt.

The thickness of the head for a finished bolt shall be equal to the thickness of the nut.

The distance between the parallel sides of a bolt-head and nut and the thickness of the nut shall be one-sixteenth of an inch less for finished work than for rough.

Now, although the fish plates and bolts properly secured to the rails will prevent them from moving lengthways, something is necessary to prevent them from moving sideways; this is done by using "HOOK-HEADED" SPIKES, which are driven into the sills or cross-ties close to the flange of the rail until their hooked heads, projecting over the flanges, will hold the rail firmly in position. SPIKES are of various sizes, styles, and dimensions, as before indicated; the writer cannot notice any of the patented articles, which, although showing some merit, generally amount to nothing. A whole library might be made up of "Railroad Equipment" alone, if including all the patents which have been issued, generally to men who know nothing at all about railroads. For example, in "spikes" alone, the writer

knows of a dozen different kinds, almost all of which, when put in use, prove utterly useless. The STANDARD SPIKE for a broad-gauge (4′ 8½″) railroad should measure 5½ inches from the tip of the point to the under side of the head, and should be $\frac{9}{16}$ of an inch square in thickness. FOR NARROW-GAUGE (3 ft.) railroads, 4½ inches by $\frac{7}{16}$ of an inch will do very well, and should be well driven, four to each cross-tie. Spikes are quoted by the pound, the present price being about 2½ cents per pound; they are packed in kegs of 150 pounds each. The following TABLE gives the number of spikes to a keg, and the number of pounds and kegs to the mile, for different sizes; from which we ascertain that a mile of single track railroad will require (using the average weight of rail, 60 pounds) 38 kegs, or 5670 pounds of $5\frac{1}{2}'' \times \frac{9}{16}''$ spikes, costing $141.75. The smaller spikes are somewhat more expensive than the larger ones, by about ½ cent per pound. A very

Railroad Spikes.

Size, measured under head.	Average No. per keg of 150 lbs.	Ties two feet between centres, four spikes per tie, makes per mile.	Rail used, weight per yard.
Inches.		Pounds. Kegs.	
$5\frac{1}{2}$ x $\frac{9}{16}$	280	5670=38	45 to 70
5 x $\frac{9}{16}$	300	5170=35	40 to 56
5 x $\frac{1}{2}$	340	4660=31	35 to 40
$4\frac{1}{2}$ x $\frac{1}{2}$	400	3960=27	30 to 35
4 x $\frac{1}{2}$	450	3520=24	28 to 35
$4\frac{1}{2}$ x $\frac{7}{16}$	510	3110=21	25 to 30
4 x $\frac{7}{16}$	540	2940=20	
$3\frac{1}{2}$ x $\frac{7}{16}$	675	2350=18	20 to 25
4 x $\frac{3}{8}$	760	2090=14	
$3\frac{1}{2}$ x $\frac{3}{8}$	890	1780=12	16 to 20
3 x $\frac{3}{8}$	930	1710=$11\frac{1}{3}$	

important feature in the construction of a railroad is involved in TRACK-LAYING. The following contract for track-laying is expressed in the usual form of such agreements.

Contract for Track-laying.

Articles of Agreement, made and concluded this —— day of —— 18—, by and between —— of the first part and the

—— Railroad Company of the second part.

WITNESSETH: That for, and in consideration of the payments and covenants, hereinafter mentioned, to be made and performed by the said party of the second part, the said party of the first part doth hereby covenant and agree to do all the Track-laying and Back-filling of the main track and sidings of the said —— Railroad Company, from —— to —— in accordance with the following specifications; and in conformity with the directions of the Engineer in charge, and to his satisfaction and acceptance; and to complete the same on or before the —— day of —— 18—.

SPECIFICATIONS.

The ties shall be laid accurately to the stakes as given by the Engineer in charge; they shall be carefully mauled down on, or into, the ballast, to such depths as the Engineer may direct, and in such a man-

ner as to give them a firm, continuous, and even bearing thereon. Care shall be taken that all ties with rind be so adzed off as to present even and parallel bearing-surfaces for the rails to rest on. The ties shall generally be laid at the rate of twenty-six hundred and fifty to the mile, but the Engineer may increase or diminish the number at such points as he may consider necessary. Particular attention must be given to the ties immediately next the joints, that they be firmly bedded into, and have a continuous bearing upon the ballast, the largest being selected for this purpose. The rails shall be accurately laid to the line, and level-stakes given by the Engineer or his Assistants, and on all curves they must be bent to the proper curvature before being laid on the ties; they shall be laid to a gauge of ——, and so as to break joints. Care shall be taken that the proper space be allowed between the ends of the rails to provide for expansion, and,

on curves, that the proper elevation, as fixed by the Engineer, be given to the outside rail. Each rail shall be securely spiked by two spikes, one on each side, to each tie; the spikes shall be well driven home, so as to bring the rails firmly down upon the ties; a greater or less number of spikes shall be used where the Engineer may require it. On Bridges the rails shall be spiked down upon the Track-stringers so as to give them a continuous bearing along their entire length, with such a number of spikes as the Engineer may direct.

The Sidings shall be laid at such points and of such lengths as the Engineer may direct, and of either new or old rails as [illegible] expedient. In putting in

upon the ballast. Each Frog shall be accurately laid with a uniform bearing upon four ties. All the backfilling that may be required shall be furnished by party of the first part, and shall consist of stone, furnace cinder, or gravel, of a size to pass through a ring of three inches diameter. After the track is firmly and accurately laid, it shall be properly surfaced, tamped, and lined up; and the spaces between the ties shall be filled with good broken stone or cinder as above specified (and as directed by the Engineer, not exceeding four hundred cubic yards to the mile) to the top and for the whole length of the ties. All material that shall have been thrown into the ditches, by the party of the first part, shall be removed therefrom, and the road properly ditched and cleaned up.

The party of the first part shall maintain and keep the track in good repair until the same is accepted by the Engineer; and no length of track shall be

ted and taken off the hands of the
of the first part, except at the option
he Engineer, until the whole shall
e been completed.

And, the party of the first part doth
ther agree to load upon cars, to be
rnished by the party of the second part,
nd transport all iron, chains, spikes, ties,
nd other material that may be required
for said track-laying from such points
along line of said railway at which they
may be piled, and to unload the same from
said cars at the nearest accessible point
to the place where the track-laying is in
progress; said loading, transporting, and
unloading to be done promptly by the
party of the first part and at his own ex-
pense. The party of the first part will
be required to insert such small open-
plank cross-drains under the railroad or
crossing roads, or at such other points as
the Engineer may direct; said drains to
be paid for by the party of the second
part at the valuation of the Engineer.

All the work that may be required to complete the track ready for the running of trains shall be done by the party of the first part, if required by the Engineer, and be paid for by the party of the second part at the valuation of the Engineer; but no work shall be done except upon the orders or instructions of the Engineer, and no claims for extra work will be allowed, unless said work was done under the orders of the Engineer, and the claim presented on or before the first day of the month next after such work was done. No extra allowance will be made for any delays that may occur in the construction of the work, but it may entitle the party of the first part to an extension of time for completing the work sufficient to compensate for the detention; to be determined by the Engineer. And the said party of the second part doth further agree and promise to pay to the said party of the first part for completing this contract as follows, viz.:—

For each and every mile of main track and siding, —— dollars.

For each and every cubic yard of back-filling, —— dollars.

For each and every Frog and Switch that may be set complete, —— dollars.

On or about the last day of every month, during the progress of the work, an estimate shall be made of the relative value of the work, to be judged by the Engineer, and upon his certificate of the amount being presented to the said party of the second part, or such disbursing agent as they may appoint, —— of the amount of said estimate shall be paid, in current funds, to the party of the first part between the tenth and twentieth of the ensuing month. And when all the work embraced in this Contract is completed in accordance with the specifications, and to the satisfaction and acceptance of the Engineer, there shall be a final Estimate made of the quality, character, and value of said work agree-

ably to the terms of this agreement, when the balance appearing due to the said party of the first part shall be paid to —— or ——, giving release under the seal of the said —— Railroad Company from all claims or demands whatsoever growing in any manner out of this agreement.

IT IS FURTHER covenanted and agreed between the said parties, that the said party of the first part shall not let or transfer this contract, or any part thereof, to any other person without the written consent of the party of the second part, but shall give —— personal attention and superintendence to the work. And it is further understood that the Engineer shall have the right to regulate, from time to time, the wages of labor upon the line of the work so as to maintain a proper distribution of the force, and prevent the injurious effects of competition among the contractors for hands.

IT IS FURTHER agreed and und[illegible] that the work embra[illegible]

shall be commenced on or about the — day of ——, 18—, and prosecuted with such force as the Engineer shall deem adequate to its completion within the time specified; and if at any time the said party of the first part shall refuse or neglect to prosecute the work with sufficient force, in the opinion of the Engineer, for its completion within the time specified in this agreement, then in that case the Engineer, or such agent as he may appoint, may proceed to employ such a number of workmen, laborers, and overseers as may, in the opinion of the Engineer, be necessary to insure the completion of the work within the time hereinbefore specified, at such wages as he may find it expedient or necessary to give, pay all persons so employed, and charge over the amount so paid to the party of the first part as for so much money paid to said party of the first part in this contract; or said Engineer may at his discretion, for failure to prosecute the work with an

adequate force, for non-compliance with his directions in regard to the manner of completing it, or for any other omission or neglect of the requirements of this agreement and specifications on the part of the party of the first part, declare this contract or any portion of it forfeited; which declaration and forfeiture shall exonerate the said party of the second part from any and all obligations and liabilities arising under this Contract, the same as if this agreement had never been made; and the reserved percentage of —— upon any work done by the party of the first part may be retained forever by the party of the second part; and it is mutually agreed and distinctly understood that the decision of the Chief Engineer of the said —— Railroad Company shall be final and conclusive, in any dispute which may arise between the parties to this agreement, relative to or touching the same, and —— said party of the first part doth hereby waive any right of action, suit or

suits, or other remedy at law or otherwise, by virtue of said covenant, so that the decision of the said Engineer shall, in the nature of an award, be final and conclusive on the rights and claims of said parties.

IN WITNESS WHEREOF, the President of —— Railroad Company hath signed the same and caused the corporate seal of the said company to be attached, and the said —— hath hereunto set — hand and seal the day and year first above written.

Attest: —— ——, { Seal of Company. }
Secy.

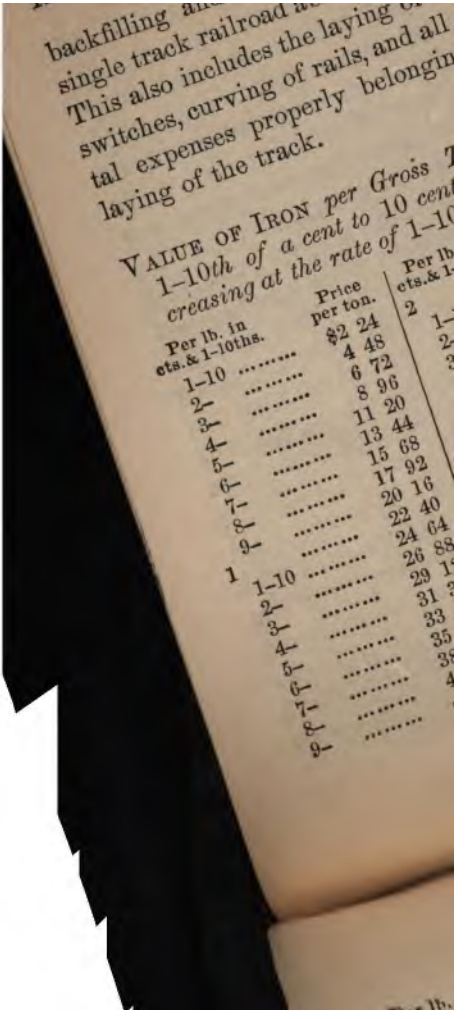
—— ——,
President.

—— ——. [SEAL.]
—— ——. [SEAL.]
—— ——. [SEAL.]

WITNESS:

—— ——.
—— ——.

In making a contract for building a railway, it is customary, when the Engineer makes his monthly statement or estimate, to reserve 10 per cent. of it until the final estimate is made, or until the work has been accepted by the Engineer, at which time it is paid over to the contractor. Great attention should be given to tracklaying, and in no instance should a contractor undertake a contract for tracklaying who is not familiar with the process or operation which he undertakes. Ignorance of the subject will be a cause of heavy losses by the contractor and endless annoyance to the Engineer and Railroad Company. A GANG OF ABOUT 40 MEN is as large a party as can work advantageously together, and one point. This gang is sufficiently ong in numbers to lay about three- rters of a mile of track per day. The re COST OF LAYING THE TRACK, in- ng loading and unloading, and trans- ig the material, together with all



backfilling and
single track railroad
This also includes the laying
switches, curving of rails, and all
tal expenses properly belongin
laying of the track.

VALUE OF IRON *per Gross*
1–10*th of a cent to* 10 *cent*
creasing at the rate of 1–10

Per lb. in cts.& 1–10ths.	Price per ton.
1–10	$2 24
2–	4 48
3–	6 72
4–	8 96
5–	11 20
6–	13 44
7–	15 68
8–	17 92
9–	20 16
1	22 40
1–10	24 64
2–	26 88
3–	29 1
4–	31 3
5–	33
6–	35
7–	3
8–	4
9–	

Per lb cts.& 1
2
1–
2–
3

			33	60	
6–	.....		35	84	5–
7–	.....		38	08	6–
8–	.....		40	32	7–
9–	.....		42	56	8–
					9–

PERMANENT WA

Per lb. in cts.& 1-10ths.		Price per ton.			Per lb cts.& 1-1
4	.....	$89	60		7
1–10	.....	91	84		1–10
2–	.....	94	08		2–
3–	.....	96	32		3–
4–	.....	98	56		4–
5–	.....	100	80		5–
6–	.....	103	04		6–
7–	.....	105	28		7–
8–	.....	107	52		8–
9–	.....	109	76		9–
5	.....	112	00		8
1–10	.....	114	24		1–10
2–	.....	116	48		2–
3–	.....	118	62		3–
4–	.....	120	96		4–
5–	.....	123	20		5–
6–	.....	125	44		6–
7–	.....	127	68		7–
8–	.....	129	92		8–
9–	.....	132	16		9–
6	.....	134	40		9
1–10	.....	136	64		1–10

over any depressions or other places where it is the expense of emb example, where earth for grading and filling quently used on rai only about one-hal bankments. Very only as a temporary in with earth as soo completed, and is i sign of a trestle va is proposed to mak

COST OF TRESTLIN

not more than 30 ning or lineal foo their constructio found along the Over swamps cheap and econ secured by dri nexed engravi stout pieces o shape. These

Fig. 6.

ng any extraordinarily heavy traffi
imbers forming this trestle may b
following dimensions:—

iles	. . .	12″ diameter.
ap	. . .	12″x14″ “
ringers	. . .	12″x14″
s	. . .	3″ planking.

he entire cost in position will not
than $2.50 per lineal or runnin
ided the timber

should be taken to drive the piles so as to come directly under the line of each rail, and the cap should be neatly mortised to the pile. Longitudinally the piles may be driven from 8 to 10 feet apart. The gauge of the road should determine the cross distances. On the Northeastern Railroad, in South Carolina, such a trestle has been in use for 25 years, and is still carrying the main track of that road. Other roads in the South also use it; notably the Savannah and Charleston Railroad. White pine is generally preferred; yellow pine where it can be procured.

On the subject of BRIDGES the author of this work is limited to a mere notice; no abridgment of so important a subject would be at all satisfactory to an Engineer, and of very little use to the unscientific reader. It is, therefore, thought advisable to simply add a few tables of reference suitable for a handbook. There are so many excellent works on bridges

that an inquiring reader can easily follow up the subject in detail for himself.

In this country iron is largely used in the construction of bridges. For approximating roughly the WEIGHT OF IRON BRIDGES we have the following from Trautwine, for spans not exceeding about 300 feet.

RULE.—(Span + sq. root of span) × 6.4 = weight *in pounds*. This means the weight of the two trusses only, as used for a single track railroad. The weight of cross girders of floor, lateral bracing, floor boards, rail strings, and rails, with their spikes, bolts, rods, nuts, washers, etc. etc., will not vary much per foot run of span, in spans exceeding about 50 feet. From this rule the following table is deduced:—

(TRAUTWINE.)

pproximate average weights per foot run
only the two iron trusses together, of a stro
rack railway bridge of the ordinary system
e weights including the floor, lateral bracin
mplete, taken at 18 *tons, or* 403 *lbs. per feet r*
n.

Weight of only the two trusses together; per foot run of span.		Weight of two trusses, roadway, etc., complete; per foot run of span.		Entire weight of bridge, an max. load per foot ru
Tons.	Lbs.	Tons.	Lbs.	Tons.
.021	47	.201	450	4.201
.029	65	.209	468	3.709
.038	85	.218	488	3.218
.046	103	.226	506	2.626
.054	121	.234	524	2.534
.062	139	.242	542	2.342
.070	157	.250	560	2.150
.086	193	.266	596	1.966
.101	226	.281	629	1.881
.117	262	.297	665	1.797
.133	298	.313	701	1.71
.148	332	.228	735	1.62
.163	365	.343	768	1.54

110	.314	569	
120	.344	636	
130	.374	703	
140	.404	771	
	.434	838	
		905	
		972	

PERMANENT

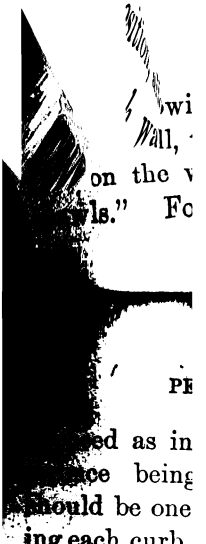
Clear span.	Weight of only the two trusses together; per foot run of span.		Weight o trusses, way, etc., plete; per run of sp
Feet.	Tons.	Lbs.	Tons.
150	.463	1037	.643
160	.493	1104	.673
170	.523	1172	.703
180	.553	1239	.733
190	.583	1306	.763
200	.612	1371	.792
225	.687	1539	.867
250	.760	1702	.940
275	.833	1866	1.013
300	.907	2032	1.087

WOODEN BRIDGES WEIGH a
ame as iron ones of equal streng

FOUNDATIONS for the abut
idges and culv

proceed

space on the wall, then
position, allowing
wide. Then place the
ing each wall as thick
a foot further or deeper
On top of this commence
"headers," running
stones set on edge, talking care
the intended space at least 12 inches
four courses for a foundation, and
in the following manner: Stake
it. An ordinary single box drain is
bank, and not become dammed up
to permit the water to drain through
the bank at any depression in the ground
of the water. The small openings placed in
CULVERTS are small openings placed in
acting under the immediate supervision
engineer who built these pieces of
elsewhere. Mr. W. m. Rogers
treated from the bot


wi
Wall,
on the
ls." Fo
PE
ed as in
ce being
ould be one
ing each curb
foot on each si
should be avoi
of the stream
should be av
masonry will
yard.

CHAPTER V.

FROGS AND SWITCHES.

nable an engine or train to pass
rom one track to another, an ar-
ient of rails and levers must be
iced, commonly termed a CROSS-
or TURNOUT. A SWITCH consists
y of two movable rails, essentially
of the main track, which can b
d so as to connect either with th
track or siding, and is made an
d "RIGHT HANDED" or "LEFT HAN
as the case may be. The wo
tch comes from the German *sweig*, s
A right-hand

called stub switches. The ends of
movable rails of a switch, being the c
or fulcrum around which they move
called the "HEELS," and the other
of the movable rails are called the "TO
The distance the toes move when
switch is being operated is called
"THROW," and is usually five inc
These movable rails, when set for
siding, form the tangents at their toes
which the turnout curve begins. T
angle with which this curve crosses
main track rails determines the size
NUMBER OF THE FROG. The FROG D
TANCE is measured from the toe of t
switch to the point of the frog. T
NUMBER OF A FROG is the proportion b
tween the length and breadth of it

plates do very well—at
ach side, to be placed under the
able rails as sliding blocks. The
ir is usually made of cast-iron to fit
end section of the two fixed rails, and
form a positive base for the movable
il to slide on, and should measure at
east 12×16 inches, and have not less
han one inch metal in its weakest part.*

The "tie rods" connecting the two mo-
vable rails are made in many different
styles, all of which have some merit, ex-
cept the kind which necessitates drilling
the flanges of the rails. It has been
proven by practice that any imperfection
existing in the flange of a rail, more parti-
cularly of a steel rail, seriously affects the
strength of the section, and is almost cer-

* On the Pennsylvania Railroad James McCrea,
Superintendent of the Middle Division, uses an im
proved chair of his own design, consisting of alte
nate layers of wood and boiler iron which give
certain amount of elasticity, and consequently
duce the wear and battering of the ends of
rails.

- the same result.
nade of square iron $1\frac{1}{2}'' \times 1''$ wi
on each end made to fit the low
he rail section is the very best
ve tie rods are generally used t
tch, and are placed five feet apart
one commencing ten inches from
of the switch. The "stand" can
of wood or iron in any variety
or size. The best are made of
weighing about 150 pounds.
target" is used the stand should
less than that, in order to have
ufficient to resist the sudden
and jarring produced in throw-
itch. Care should be taken
the switch to have the stand
ed with two or more screw
through

should be supplied with a sleeve-joint to admit of tightening up as it becomes loose by wear and length of service. Where the stand and target would take up too much room, the ground lever can be used to advantage. It is so familiar to all railroad men as to require no further mention. A "three throw," or, as it is often incorrectly termed, a "double throw" switch, does not differ materially from the single stub switch described above, except simply in the "chairs," which are made larger to allow the introduction of an additional rail. All switch stands are made for a "three throw" switch, and are used for both kinds. The stub switch has also been made practically a safety switch by means of additional castings so arranged and fastened to the switch that they receive the wheels of the engine, when they leave the track by accident, and guide them safely back again. There are several modifications of this principle, but in the main idea they are simi-

lar. At the best they are clumsy unmechanical contrivances, and can rarely be depended on to do the work intended. There are a very few exceptions, but the first cost of these is in most cases too great to admit of their use.

Although a comparatively safe switch on our leading railroads, where they are well protected by signals and other modern appliances, the stub switch is in itself an imperfect, dangerous switch and open

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Although a comparatively safe switch on our leading railroads, where they are well protected by signals and other modern appliances, the stub switch is in itself an imperfect, dangerous switch and open to many serious objections, the principal one being the noisy open joint causing enormous wear and tear of the rolling stock and destructive mashing of the rails. Even by exercising the utmost care the joints formed by the movable rails will prove a source of endless annoy- terlocking by

rods which are used to operate the switch, and in such a manner that any strain coming on the rods is received by them, and owing to their elastic nature is rendered harmless. The split rail switch, as shown in the figure, is operated as follows: In the diagram the switch is shown set for the siding. A represents a continuous rail belonging to the side track, and D the continuous rail of the main track, both of which are unbroken rails, perfect in their entire length. This is one of the chief merits of the switch, as in either case, whether set for the siding or for the main line, one of the rails will be continuous and unbroken, and consequently no jarring or noise is experienced when running over it. B and C represent two rails which are planed and made pointed, so as to fit up closely to the rails A and D. These two pointed rails are clamped together by tie rods (usually five in number) so as to be thrown in the same direction and at the same time by means

of any common lever at E. By means of this lever the switch is operated. It will readily be observed that if an engine should attempt to pass from right to left on the main track while the switch is set for the siding, as shown in the diagram, the flanges of the wheels will go between the rails D and C and force them apart, and the rail D being immovably spiked down to the sills will not move, so the pointed rail C must move, and also its opposite B, both being clamped together and only held in position by the connecting rod of the lever which will break or yield, allowing the flange to pass through, the engine consequently keeping on the track. In like manner the flanges of the wheels will operate against the rail B should a train attempt to pass *out* of the siding when the switch is set for the main track. To avoid this injury to the switch, that is, the breaking of the connecting rod, a spring has been introduced, indicated at F in the figure, which allows enough move-

ment to make space enough for the flanges to pass between the rails, and which, after they have done so, by their elasticity draw the pointed rails back again into position for the main track. This spring Mr. Lorenz makes of rubber, and for many years has used it on the Reading Railroad. Some other roads, however, use coil springs of steel, which answer the purpose probably as well.

For a double track railroad where the trade is generally moving in one direction and on its own line of rails, this switch is unquestionably the best in use; many years of experience and trial have proved its superiority over other safety switches; but on a single track railroad where the switch would have to take the trade at both ends, the objection is raised of

$110 per set, including everything and ready for laying in the track. When ordering it is necessary to designate whether a right or left handed switch is wanted. The following table for correctly laying a Lorenz Switch is added for the use of Roadmasters and Engineers.

Table for Laying the Lorenz Safety Switch.

(Matthews.)

Switch Angle, 1° 30′.

Throw of Switch is the distance between flange sides of main track and switch-rails at heel of switch.

Frog Distance is the distance from heel of switch to point of frog, measured diagonally across the track.

	20 foot Switches.	24 foot Switches.	Switches. 30 foot.
Switch angle,	1° 30′	1° 30′	1° 30′
Throw of Switch,	6¼ inch	7½″	9¼″
Frog Distance,	55 feet.	53′8″	51′7″
Radius,	556.64	542.78′	521.6
Degree of Curve,	10° 18′	10° 34′	11° 00′
Mid-ordinate,	8¼ inch.	8″	7¾″

N. B.—20 foot Switch means, with point-rails

N. B.—20 foot Switch means, with point-rails 20′ long, etc.

To meet the objection raised against the Lorenz Switch that "it is dangerous to run against the points," Mr. Ainsworth, Roadmaster of the North Pennsylvania Railroad, invented and patented a switch, as shown in the figure. The switch is constructed by bending the main track rail A so as to receive the blunt pointed switch rail B when shut, which forms the lap of the rails at that point. The short or tapered switch rail C is made in the usual manner, and both are

decline to the proper level of the track. At the ends of the rails C D are placed two castings respectively at *b*, which, in case an engine should run *out* of the siding with the switch set for main track, receive the wheels and guide them back again to the main track. When the switch is set for main track, as shown in the figure, the curved rail E lies away from the rail B, but when set for the siding the same motion of the lever throws it over against the rail B, where it remains as long as the switch is set for the siding. Now, supposing a train to be coming on the main track from right to left, and the switch set for the siding, the first wheel flange will force the rail E away from the rail B, and consequently by means of the connecting rod *e*, will throw the lever W, and so leave the main track clear and unobstructed. The chief objection brought against this switch is, that it will not admit of fast running both ways, and is therefore exclusively a main

rock [illegible] rate of s
the main track rails. This objecti
t in a great measure by the fact th
sing in or out of a siding the trai
lly "slows up," and consequently
over the switch quietly. THE
the switch complete is about
set, ready for laying in the

GLE TONGUE SWITCH" is more
nown in this country as the
witch, owing to the fact that
yer, of Baltimore, patented
provements on the original
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nstruction it differs from
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steel castings, and although a suitable lever is much preferable, it can be used without one, the movable rail being easily moved by the foot. The switch is shown in the figure set for the main line, in which case the rail D acts as a guard rail, and, causing the wheel flanges to pass through the throat *c*, in a line parallel to *a*, keeps the wheels in the main track rails A E. Now in order to set the switch for the siding it is only necessary to close the tongue D against the main rail A, thereby necessitating the passage of the wheels over the rail D, and consequently the flanges of the opposite wheels through the throat *b*, past the point E, and so on to the siding rails D B. Or should the switch by accident be left set for the siding, and suppose a train on the main line passing from right to left; as soon as

opposite rails E and B being arranged as in a frog, readily carry the other wheels from E to B; or *vice versa* if left set for main track, and a train should come down the siding. The switch works well in either case, and is a safe, reliable switch, more particularly adapted for yards, but doing good work wherever it is put, in a yard or main track. For fast running it is hardly suitable, as the continuity of the main line is broken by the frog point at E. The simplicity of its construction, coupled with the fact of its perfect safety, makes it a general favorite among railroad men. The cost of the single tongue switch complete is $90, including all attachments, per set. The Baltimore and Ohio Railroad Company have in use a great number of these switches, but have now discontinued laying them, using instead a switch invented by Mr. John L. Wilson, Roadmaster, which in design and operation is very similar to the Lorenz switch. The enormous weight of the

machinery on this road necessitates very heavy track material, and a preference is given to this switch because the tongues can be made much heavier and stronger of forged steel than is possible when using a planed T-rail. The cost of making this switch is somewhat more than the single tongue and Lorenz switches, owing to the heavy forged steel tongues, which must be first hammered and then planed to shape.

The MOVABLE GUARD SWITCH is better known as WHITE'S SAFETY SWITCH, and is different from other switches, having both of the points fixed, and moving instead the two guard rails which are usu-

switch is incorrectly termed the Tyler switch, as it was invented in the year 1842, by Mr. G. A. Nicolls, at that time connected with the Reading Railroad, and at present President of the Reading and Columbia, East Pennsylvania, and other railroads, and was in successful operation on many railroads in this country and in Cuba, when he received a patent for it in 1845. Afterwards Mr. Philos P. Tyler, of New Orleans, obtained a patent for the same device. The switch has been extensively used on the Reading Railroad, and was well known some years ago as the "NICOLLS' SAFETY SWITCH." It consists simply of two extra rails with castings at their ends so arranged that, if the switch should be left wrong, these extra rails will receive the wheels of the engine and train, and the castings will guide them safely back on to the main track. It is very economical, and could be applied to any stub switch now in use by an additional trifling cost for the extra rails and costing say $10 for each switch.

With each switch a "frog" is a necessary adjunct. The word FROG, as applied to the railroad contrivance, is so named on account of its supposed resemblance to the frog of a horse's foot. Originally a frog was nothing more than a swinging rail pivoted in the centre, A, as shown in the figure; but now a frog is a casting or other mechanical contrivance to enable the wheels of a moving train to pass over, by, or through a point where the rail of a siding necessarilly crosses the rail of the main track (see fig. 16). There are two classes of frogs, called the STIFF FROGS and SPRING FROGS. The former denotes a solid casting or combination of pieces bolted stiffly together, and which when spiked down in the track remains immovable, while the latter term implies a frog having some of its parts arranged so that they are adjusted by springs, and the action of the wheel flanges when passing over it sets it right for the tread of the wheels to ride over. Knowing the

ous cases where turnouts cross tracks in various directions in and about stations, depots, etc." Mr. Trautwine, in his usual concise, lucid manner, gives, in his "Engineers' Pocket Book," some extremely simple forms for laying out a curve by eye, which are very useful. Ordinary cast-iron steel plated stiff frogs of the average size (No. 8) will cost about $30 apiece. An objection to their use is the difficulty experienced in keeping them in position; being short and entirely distinct from the rails, the weight of the cars soon causes a rocking motion which tends to loosen the spikes which hold it in position. An improvement in this frog is the steel rail frog (see fig. 18), which is made up of the ordinary pattern of steel T-rails in many different styles and shapes, but

this frog (No. 8) is now as low as $28 apiece. THE SPRING FROGS are used to avoid crossing a channel or the throat of the frog, and to give a continuous even bearing to the wheels when passing over it. This is done by means of springs so fastened to the frog that the flanges of the wheels operate against the rails, and shift them into such a position that the tread of the wheel will always ride on a smooth even bearing, and will not have to cross any channel. The manner of working it is as follows: The rail A (fig. 19) and the rail C, forming together the point of the frog, are securely dovetailed together, and then riveted down to a base plate of wrought iron *a*. The wing rail D is also riveted to this plate sufficiently far from the point to allow the easy passage of a

f which passes through oval slots in the two wing rails, and also the point. The frog is always kept set right for the main line by means of the rubber springs, and it will readily be observed that a train passing from A to B will do so over a smooth unbroken surface, securing much comfort to passengers, and a great saving in wear and tear to motive power and rolling stock. In passing from C to D, or on the siding, the flange of the first wheel, as soon as it reaches the wing rail B shoves it aside far enough to pass through, and each subsequent wheel in like manner, the springs allowing the necessary motion by compressing, and then (after the wheels have passed through) drawing the wing back again by their elasticity. In like manner a wheel returning from D to C

Pennsylvania Railr
leading roads. Th
15 feet long, and c
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are made like stiff fr
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A CROSSING i
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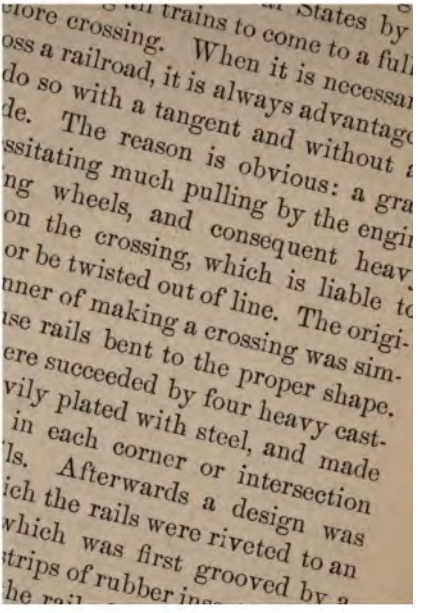

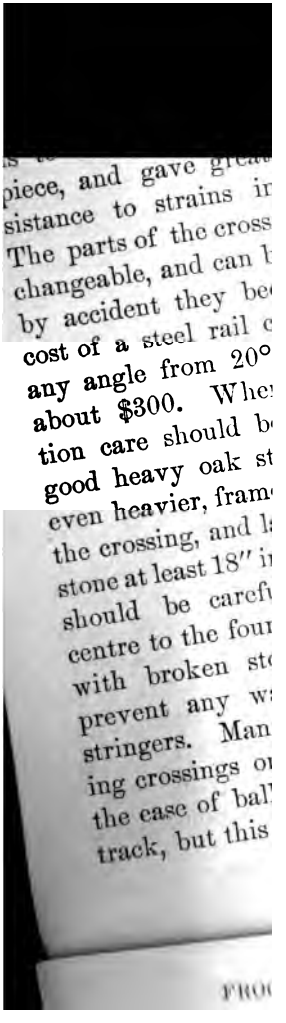

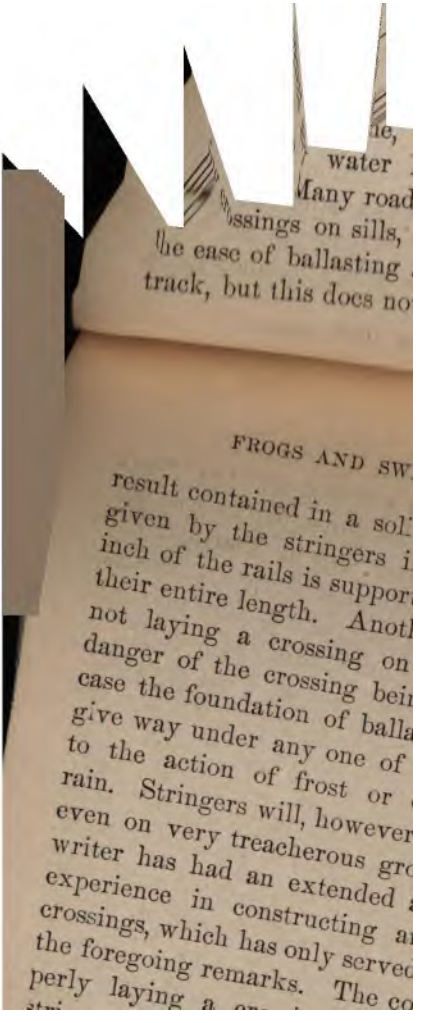

of switches, the proximity of depots or stopping places, or of any reasons why the engine should proceed or stop. Switch signals are usually made with the stand of the switches, and are called targets, the switch being altered or changed in any direction shows a corresponding change in the position of the target, which being placed at some elevation above the rails is easily seen by the engineer, and shows him how the switch is set. A FIXED SIGNAL is a vertical post planted alongside the track, and by means of movable arms operated in a great many different ways, the engineer is notified how to proceed with his engine and train. It is not within the field covered by this work, or a detailed description of signals would be given. The subject admits of an extended description. A brief mention of the subject is made simply because calculations regarding the cost of building and operating a railroad necessarily involve signals. The arms of a fixed signal are

usually painted red, blue, and white, signifying, first—*Red:* "Danger, stop!" *Blue:* "Caution, proceed slowly." *White:* "All right, go ahead." With the exception of using green for blue, this is the general interpretation of the colors. In placing fixed signals it is necessary to do so with a view to having a good background—the sky is the best—but sometimes trees or a deep cutting will prevent this, in which case an artificial background of boards painted white, or the rocks of a cutting, or the abutment of a bridge whitewashed, will tend to show the arms of a signal distinctly. On the

red, blue, or whi
proaching train, l
engineer how to
painted boards
lights.

Another clas
foggy weather,
obstructed at p
signals, consist
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These little bo
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over them the
port, promptly
"danger ahea
are too compl
nor could th
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briefly defin
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lower for a particular train, but he
not lower such a signal or produce
a combination of position of p
(switches) and signals as would, if
signals were obeyed, produce a collis
Saxby and Farmer's system of i
locking signals is probably the be
use. THE BLOCK SYSTEM of signa
briefly illustrated as follows:—

Suppose a line of railway to be div
off into a certain number of districts
telegraphic stations, for example, a
divided into three stations, calling
stations A, B, and C, points where t
signal boxes are established. A t
leaves A, and at the same time B is n
fied of the fact by means of the telegra
B answers back to A, "All right"

line is then "blocked" until the train arrives at B, that is, no other trains can run from A to B until its arrival; as soon as it arrives at B, the agent at that point notifies A of the fact, and "raises the block" between A and B, leaving the line clear. In the same manner the train proceeds from B to C, and so on through each district until it has reached its objective point. The safety and security of the block system is obvious—for supposing a train should break down or become disabled in any of the districts, say between B and C, then the "block" is continued at B, and no train can pass beyond B until the block is raised by C, which cannot be done until the disabled train has reached that point. This is the principle of the "block system," and is involved in all the improvements which have been made on it. If strictly adhered to no collision can possibly take place, as a space is always preserved between each train equal to the length of each district.

CHAPTER VII.

EQUIPMENT.

In the earlier history of railways, horses were used to pull the cars which ran on tramways constructed of wood. In the year 1767, iron was substituted for wood. In 1802 Messrs. Trevithick and Vivian patented a plan for a locomotive, which ten years afterwards was put into operation. In 1811, a patent was taken out by John Blenkinsop, of Middleton, Yorkshire, England; for certain mechanical means by which the conveyance of coal and other articles was facilitated, and the expense attending the conveyance of the same was rendered less than before. It consisted in the application of a racked or toothed rail on one side of the road from end to end; into this rack a toothed wheel was worked by the steam engine,

the revolutions of which produced the necessary motion without being liable to slip in descending steep inclined planes. Several of the engines were made in the years 1812 and 1813, but in the year 1814 the rack rail was abandoned, as it was found by Geo. Stevenson that the wheels adhered to the track sufficiently to do the work without it. The Liverpool and Manchester Railway was commenced in the year 1826, under the direction of Geo. Stevenson as Engineer. After mature deliberation the managment determined to have *locomotive* in preference to *fixed* engines for motive power, provided the former could be made sufficiently powerful, and that the weight were not so great as to injure the rails; also, ones that would not emit smoke. In 1829 a reward was offered for the best engine under the following conditions, viz., to consume its own smoke, to draw three times its own weight at 10 miles an hour, with not over 50 lbs. pressure of steam

on the boiler; to have two safety valves (one locked), the boiler to be supported on springs, and to rest on six wheels if it weighed more than four and one-half tons: height to top of chimney, not over fifteen feet; weight, with water in boiler, not to exceed six tons (less preferred); boiler proved to three times the working pressure, and not to cost more than £550. This competitive trial resulted in the success of the "Rocket," and the prize of £500 was awarded to Geo. Stevenson. The superiority of the "Rocket" was due in a great measure to the boiler having small tubes, and to the blast from the exhaust steam enabling the engine to generate steam as fast as required. It is claimed that the flue boiler was suggested by Henry Booth, the treasurer of the company. From other information it appears that the tubular system of boilers was invented in both England and France at the same time. In 1835 Robert Stevenson took out a patent for leaving

the flanges of the driving wheels, and
ng flanges on the leading and trail-
g wheels only. Richard Trevithick
aims to have invented the steam blast,
ut the claim has been disputed by
George Stevenson and Timothy Hack-
worth. India-rubber springs for sustain-
ing the weight of locomotives were pat-
ented by the Earl of Dundonald, in 1835.
The history of the locomotive is an
exceedingly short one, but rapid strides
have been made towards perfection in
its construction, and particularly by
American manufacturers. For all infor-
mation concerning the details of construc-
tion and other information regarding the
locomotive, the writer recommends a
careful study of "The Catechism of the
Locomotive," by M. N. Forney, Mechani
cal Engineer. The subject is an important
one, and every railroad man should be
familiar with the lever which operates
his road. The cost of a first-class pas-
senger locomotive of the "American"

pattern, as built by the Baldwin Locomotive works of Philadelphia, ranges from $7000 to $8000, supposing the road to be of the ordinary guage of 4′ 8½″. The following dimensions of this style of locomotive are reliable.

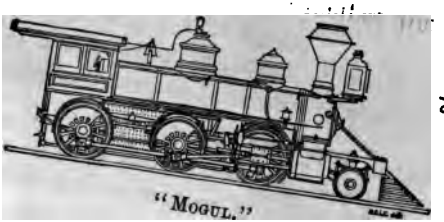
"AMERICA."

Number of driving wheels,	4
" front truck wheels	4
" back " "	None.
Total wheel base	21′ 9″
Between centres of front and back driving wheels	96 inches.
Total weight of locomotive, working order	65,000 lbs.
Total weight on driving wheels	42,000 lbs.
Diameter of driving wheels	60¾ inches.
" truck "	28 "
" cylinders	16 "

Stroke of cylinders	24 inches.
Outside diameter of smallest boiler ring	48 "
Size of grate	65″×34½″
Number of tubes	144
Diameter of tubes	2 inches.
Length of tubes	10 ft. 11 in.
Square feet of grate surface	15.5
" " heating surface in fire box	100.6
" " heating surface in tubes	825.4
Total feet of heating surface	926.0
Exhaust nozzles (single or double)	Double.
Diameter of nozzles	2¾–3¼ in.
Size of steam ports	1¼×15 "
" exhaust ports	2½×15 "
Throw of eccentrics	5½ inches.
Outside lap of valve	¾ inch.
Inside " "	1/32 "
Size of main driving axle journal	7″ dia.×8″
" other " " "	7″ dia.×8″
" truck axle journal	4½×7½ in.
Diameter of pump plunger	2 inches.
Stroke of pump plunger	24 "
Capacity of tank	2000 gall.

The style known as the "Mogul" is used for freight purposes, and its cost ranges from $8000 to $9000.

The following are the principal dimensions:—



"MOGUL."

Gauge of road	4′ 8½″
Number of driving wheels	6
" front truck wheels	2
Total wheel base	22′ 8″
Distance between centres of front and back driving wheels	96 inches.
Total weight of locomotive	77,000 lbs.
" on driving wheels	66,000 "
Diameter of driving wheels	52 inches.
" of truck wheels	30 "
" of cylinders	18 "
Stroke of cylinders	24 "
Outside diameter of smallest boiler ring	50 "
Size of grate	66″×34½″
Number of tubes	161
Diameter of tubes	2 inches.
Length of tubes	11′ 3″
Square feet of grate surface	16′ 0
" " of heating surface in fire box	102.7

Square feet of heating surface in tubes	948.0
Total square feet of heating surface .	1051.0
Exhaust nozzles	Double.
Diameter of nozzles	3″ to 3½″
Size of steam ports	1¼×16″
" exhaust ports . . .	2½×16″
Throw of eccentrics	5½ inches.
Outside lap of valve	¾ "
Inside " "	1/32 "
Size of main driving axle journal .	7″ to 8″
" other " " " .	7″ to 8″
" truck " " " .	5″ to 8″
" pump plunger . .	2 inches.
Stroke of pump plunger . . .	24 "
Capacity of tank	2200 galls.

The third style of engine, also a freight engine, is called the "Consolidation." The following dimensions of this class of locomotives is from the Danforth Locomotive Works, Paterson, New Jersey. The cost of this locomotive will range from $9000 to $10,000 for standard (4′ 8½″) gauge.

"CONSOLIDATION."

Gauge of road	4′ 8½″
Number of driving wheels	8
" front truck wheels	2
Total wheel base	23′ 2″
Distance between centres of front and back driving wheels	15′ 7″
Total weight of locomotive	96,550 lbs.
" " on driving wheels	86,430 "
Diameter of driving wheels	4′ 2″
" truck wheels	2′ 7″
" cylinders	20″
Stroke of cylinders	24″
Outside diameter of smallest boiler ring	4′ 2″
ize of grate	120″×34¾″
umber of tubes	165
ameter of tubes	2¼″
gth of tubes	13′ 9¼″
are feet of grate surface	29
" heating surface, fire box	139
" tubes	1370

tal feet of heating surface . .	1509
haust nozzle	Double.
iameter of nozzle	$3\frac{1}{2}''$
ize of steam ports	$1\frac{1}{2}'' \times 15\frac{1}{2}''$
" exhaust port	$2\frac{3}{4}'' \times 15\frac{1}{2}''$
Throw of eccentrics	$5\frac{1}{2}''$
Outside lap of valve	$\frac{5}{8}''$
Inside " "	None.
Size of main axle journal . . .	$6\frac{3}{4}''$
" other driving axle journal .	$6\frac{3}{4}''$
" truck axle journal . . .	$5''$
Diameter of pump plunger . .	$2\frac{1}{4}''$
Stroke of pump plunger . . .	$24''$
Capacity of tank	2400 galls.

Regarding the other dimensions, the *height of the stack* is usually from 13 to 15 feet above the rails. The *tenders* of engines will weigh about 6 tons empty, and about 15 tons full of water and fuel. Width of tender 9 feet, and length about the same as the engine. The price given for the locomotive is supposed to include the tender.

THE FIRST RAILWAY CAR ever used for carrying passengers, was built in 1825, and was run on the Stockton & Darlington

Railroad, in England. It was simply a common box-car made of wood, with three windows on each side, and mounted on four fixed wheels. The English cars, even at the present day, vary but little from this design; but the American cars are constructed on an entirely different principle, having two swinging or bogie trucks under each end. AN AMERICAN PASSENGER CAR measures about 50 feet in length from out to out of bumpers, with an extreme width of about 10 feet. The trucks have four, six, and sometimes eight wheels each. A car will hold 60 passengers comfortably, and when empty will weigh about 15 tons, when filled with passengers, about 19 tons.

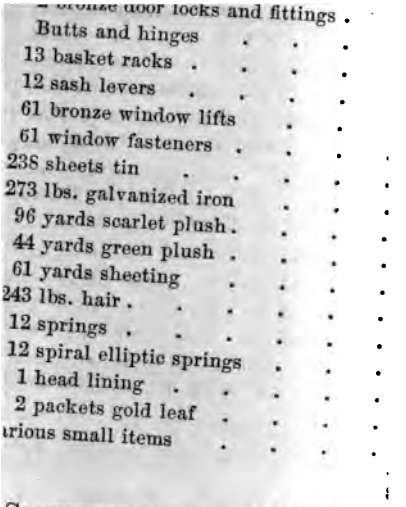
Cost of a Pennsylvania Railroad Passenger Car.

The London *Engineering* gives in detail cost of constructing one first-class dard passenger car, at the Altoona s of the Pennsylvania Railroad, the

cost being $4423.75. The principal
as are as follows:—

r	$1263 94
portion of fuel and stores	28 61
0 feet poplar	86 80
4 feet ash	127 08
0 feet pine	20 90
50 feet of yellow pine	70 50
00 feet oak	10 00
450 feet hickory	13 50
700 feet Michigan pine	49 00
400 feet cherry	16 00
439 feet maple veneer	24 14
4 pairs wheels and axles	332 85
2 pairs passenger car trucks, complete	533 62
13 gallons varnish	52 34
45 lbs. glue	14 33
2925 lbs. iron	87 75
792 lbs. castings	16 99
Screws	51 88
Gas regulator and gauge	25 2
2 two-light chandeliers	50 7
2 gas tanks	84 0
1 air-brake, complete	131
57 sash balances	44
61 lights glass	65
2 stoves	77
25 sets seat fixtures	50
3 bronze lamps	13

EQUIPMENT.



SLEEPING CARS are about the
e as ordinary ones, but some hav
nstructed 70 feet long by 11 f

from $1500 to $2500 each. FREIGHT BOX-CARS measuring 30 feet in length and 9 feet in width, with 8 wheels, will weigh about 8 tons, and cost about $500 each. Platform or GONDOLA CARS of the same dimensions weigh about 7 tons, and cost about $350 each.

Average Weight of Cars.

4 ft. 8½ in. gauge, as in use on principal railways in the United States.

	Weight.
Baggage car, 36 feet out to out,	28,000 lbs.
Mail " " " "	32,000 "
Passenger " 48 " "	37,000 to 39,000 "
Sleeping " " " "	41,000 to 44,000 "
Stock " " " "	17,500 to 18,500 "
Box, " " " "	16,400 to 17,800 "
Flat " 32 feet long,	16,500 "
8-wheeled coal cars,	13,440 "
4 " "	6,720 "
Iron trucks for passenger cars,	16,000 "
Wooden trucks for passenger cars,	14,000 "
Passenger car axles, of iron,	330 "
" " steel,	320 "
Freight " iron,	300 "

A freight car will carry from 10 to 15 tons of weight. Coal cars usually carry about 5 tons of coal for the smaller, and 10 for the larger cars.

Weights of Substances.

Salt	℔ bushel	80	lbs.
"	barrel	280	"
Cement	"	300	"
Water	gallon	8.33	"
Oil	"	7¾	"
Alcohol	"	6.96	"
Turpentine (spirits)	"	7.31	"
Powder	keg	25	"
Coal, anthracite	bushel	86	"
" bituminous	"	80	"
Coke	"	32	"
Charcoal (hard)	"	30	"
Asphaltum	c. foot	56	"
Gutta percha	"	61	"
India-rubber	"	60	"
Ivory	"	112	"
Pitch	"	71	"
Rosin	"	68	"
Tar	"	62	"
Sand	"	120	"
Slate	"	175	"

" " shale
" " granite
" " slate

COAL CARS havin
weigh about 3 ton
feet long by 6 fe
$180 each, and wi
of coal. The ma
foregoing freight c
is 12 tons. THE
and freight cars a
inches in diamete
ters have been
wheels have be
inches in diamet
wheels are usu
one piece, and
hub with a d

made with single, and others with double plates, and still others with spokes similar to a driving-wheel. The tread of the wheel is hardened by a process called *chilling*. This is done by pouring the melted cast-iron into a mould of the form of the tread of the wheel. The mould is also made of cast-iron, but being cold cools the melted iron very suddenly, and thus hardens it somewhat as steel is hardened when it is heated and plunged into cold water. Only certain kinds of cast-iron will harden in this way—the cause is not known.

The Taylor Iron Works at High Bridge, New Jersey, manufacture a good pattern of cast chilled wheels, such as are used on most of the American railroads. The manufacture of these wheels is an industry requiring long experience and nice judgment; not only as to the character of the irons used, but also regarding their combination, so as to secure all the qualities required in the

product. The extent to which this industry has grown can be judged by the following statistics. There are in daily use, on the 75,000 miles of railway in the United States, 15,680 locomotives; 14,621 passenger and baggage cars; 384,903 freight cars; which use 3,500,000 wheels. The average load on a passenger car wheel is about 3 tons, and the average life of a wheel is about 50,000 miles; on fast passenger trains a wheel lasts about 10 months, but on freight cars a wheel will last from 3 to 10 years. Assuming the average life of wheels at 5 years, the total number of wheels worn out annually in the United States alone, will be no less than 700,000; which, at an average of $13 per wheel, will cost $9,100,000 allowing ⅓ of this for the value of old wheels, the annual loss may be stated about $6,000,000.

All kinds of chilled cast car wheels are embraced in the following forms, viz: double plate, single plate, and spoke

for securing an even
chill on the tread, freedom from
nd a maximum strength for the
f iron used, much more depend
e proper selection and manipulat
iron to be used. Charcoal pig
ssessing the greatest strength and
ing properties, is exclusively use
rst class manufacturers of whe
the anthracite irons, some of wh
hill, are used to a large extent
s of inferior wheels. The wearin
or tread of the wheel is chille
de exceedingly hard by running
en metal into iron moulds which
n previously turned to
rm. To mak

better than doub
should be bright
fibrous looking,
the gray iron bac
hard, the wheel w
of 100,000 miles
charcoal iron po
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the chill
and ragge
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of diff
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grades of i
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simply made ir
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others, the des
At the foundry
the several k
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is also taken

easily are charged s
same time as the more
iron is drawn from th
reservoirs, holding fr
each, and thoroughly
before and during th
wheels, and, being pou
possible temperature,
ness of tread and a to

pth, having also strer
freedom from strain. T
ties are further increased
four days in air and mo
made of iron cylinders le
ground, and lined with
wheels are then taken fi
cleaned with wire brush
they are carefully inspecte
for sale.

Cast-iron wheels weigh

Spoke	wheel,	14″ dia.	3″ t
“	“	16 “	3
Single plate	“	18 “	$3\frac{1}{2}$
“ “	“	20 “	$3\frac{3}{4}$
“ “	“	24 “	$3\frac{3}{4}$

Double plate wheel,
" " "
" " "
" " "
For
pas
" " "
" " "

CAR WHEEL
cents per pou
about an aver
wearing out;
have shown
twice as muc
miles, howev
mileage for
iron wheels
used for pass
tenders and
advantage fr
tread of the
by wear, it c
to a true bea
wheel, inve
constructed

between the body
tire, and possesses
One of these wheel
meter, was run unde
car somewhat over
two years' service,
tire was turned off
of an inch of its dia
wheel is worth abou

Table of Stee

33″ diameter,		4″ t
33	"	$4\frac{3}{4}$
30	"	4
30	"	$4\frac{3}{4}$

The car, engine
AXLES require espec
chasing—quality bei
than price. As mac
viously referred to, t
the requirements of
hammered from sele
iron, which is first n
of rust, thereby secur

welding in the subsequent operation of shingling, faggoting, and swedging into form; the journals being hammered in to secure a denser and harder bearing surface. Driving axles are used from 5 inches to 8 inches in diameter; engine truck axles, from 4¼ to 5½ inches diameter; and locomotive tender and passenger and freight car axles, from 4 to 5 inches diameter, and having a length of from 6′ 6″ to 8 feet. The concave form of axles, which can only be obtained by hammering, is preferable, for, by distributing the vibrations, the shoulder of hub seat is relieved from the liability to fracture. Axles made of old rails are very inferior in quality, and, consequently, can be sold very cheap—at about 2½ cents per pound, while the best kind of hammered axles, made from selected scrap, are worth about 3 cents per pound. The corners of the wheels are reamed out by revolving table drills, and the journals and wheel seats of the axles are also

carefully turned off on a lathe, after which the wheels are pressed on to the axles by a hydraulic machine at a pressure of about 30 tons weight.

WROUGHT-IRON FRAMES for the trucks of cars will weigh about 175 pounds each, and cost about 6 cents per pound, finished and fitted together. There are two frames to each truck, these two constitute a "set." COUPLINGS of wrought iron are sold by the pound, and vary in price according to the market. SPRINGS are nade of the best crucible cast-steel, and 1 various forms and shapes. Springs ade of round steel, and of spiral shape, much used, and cost as follows:—

iffer or draw springs, 11 cents per lb.
lster springs, in sets of 4 springs, $20 to $30
t.
alizing bars springs, in sets of 8 springs, $30
per set.

be required to arrest the speed ain, the BRAKES are applied, and n is stopped. Various kinds of

[illegible]ave been in use both in this country and abroad, differing from each other in the construction, but generally alike in regard to the kind of power employed to operate them. One kind of brake is known as the SLIPPER BRAKE, and consists of a contrivance by means of which friction is produced between the brake block, or slipper, and the rails. Another brake is applied directly to the wheels, as in an ordinary road wagon. Still another kind is a clip which is attached to the car, and by means of screws and levers is made to grip the rail firmly between the arms of the clip. Again, there are brakes operating directly on the axle, instead of the tread of the wheel; but the usual manner of operating brakes is by the strength of the brakeman's arm operating a set of levers, which causes the brake blocks to press close up against the tread of the wheels, and so stops their motion. This manner of braking injures the wheels to a great

extent, sometimes by locking the wheels so that they remain immovable, and slide along the rails, making flat places on their periphery. On passsenger trains, however, the AUTOMATIC OR CONTINUOUS BRAKES are now extensively used, which are so arranged that the engine driver can apply the brakes of all the cars simultaneously; they are also so constructed that should the cars by any means become uncoupled, the same action will immediately apply the brakes on the detached car, and so arrest its motion. THE WESTINGHOUSE BRAKE is constructed on this principle, and so is the LOUGHRIDGE. The power used is simply compressed air, which is conveyed by pipes from the receiver, which is attached to the locomotive, to every car, at which point it enters a cylinder, and, operating on a piston and levers connected with it, so applies the brakes. The air is compressed by means of a steam pump on the engine, and the receiver is a receptacle for the

compressed air until it is required to use it. Experiments made in England with the Westinghouse automatic brake resulted as follows: A train of thirteen carriages, travelling at the rate of 52 miles an hour, was brought to a full stop in *19 seconds!* The distance run from the time the brakes were applied until the train stopped was 913 feet. The time formerly required to stop a train in England by hand brakes, train running at the rate of 49½ miles per hour, was from 60 to 90 seconds, and in a distance of from 2000 to 4000 feet.

LOUGHRIDGE claims the best stop yet made, in a trial on the Baltimore and Ohio Railroad, in which a train of ten cars travelling at the rate of 42 6/10 miles per hour was stopped in 16 seconds and after running only 587 feet 8 inches. The cost of equipping a train with these brakes is comparatively trifling. The railroad companies usually pay the inventor for the right to use the brake per

mile of road, or per car, or whatever other form of royalty they choose to pay, and then make the brake apparatus, and fit it to their cars in their own shops. Other brakes operated by water, or by creating a vacuum, are in occasional use, but are inferior to either of the above. SMITH'S VACUUM BRAKE, however, showed very good results in a competitive trial—Clark's "hydraulic" also.

CHAPTER VII.

DEPOTS AND STRUCTURES.

is highly important when building a
oad to consider well what depot fa-
ies are *necessary* to accommodate the
siness of the road, and not how much
oney can be wasted in a ponderous un-
ghtly pile of brick and stone, oftentimes
nmeasurably inconsistent with the busi-
ness to be transacted therein. PASSENGER
STATIONS should be made with a view to
the comfort of passengers. The tracks
upon which the trains arrive and leave
should be systematically arranged for
"outward bound" and "incoming" trains,
with separate and distinct platforms and
exits for each class of passengers, either
those arriving or departing. The writer is
quite familiar with a railroad company
having its terminal depot in one of our

large cities, where the passengers arriving alight from the cars into the middle of a filthy, cobble-stone street, and on rainy days they wade over to the pavement as best they can. A covering should always be provided amply large enough to cover the standing trains, both arriving and departing; under this same covering, sufficient offices for baggage, waiting-rooms for ladies and gentlemen, and a well-ordered restaurant should be provided. The cost of such a depot will, of course, vary considerably, so much in fact that no very near estimate can be given. The value of the property not being taken into consideration, however, the building itself need not cost more than $10,000. While first operating the road, more attention should be given to the improvement of the roadbed than to the depots, but at all times there is no excuse for not making the passengers comfortable while waiting for arriving or departing trains.

In the construction of a FREIGHT DEPOT

the most important feature is to consider the easiest possible way of landing and transferring the freight which is to pass through it. All known mechanical contrivances for facilitating the handling of the particular kind of freight which the road is intended to carry should be carefully examined by the Engineer, and the merits of each carefully weighed in his mind with a view of adopting whatever may be of value. Sufficient siding room should be provided for empty cars waiting to be loaded, and these sidings should be arranged with a grade descending in the direction in which the cars are to move, so that the men employed around the building can easily move them without the expense of a shifting engine. All these little details must be thought of and provided, and every Engineer will have to study out his own plan of a freight depot to suit his own particular case. WAY STATIONS, as a rule, need only be small buildings sufficiently large to protect the

passengers from the weather, and also of sufficient capacity to store away a limited amount of freight. It is quite common to have a building for a way station so arranged that one-half of it can be occupied by the station agent and his family, leaving the other half for depot purposes; such a building need not cost more than from $3000 to $5000, according to the style in which it is built. FLAG STATIONS are small settlements where little or no freight business is done, and where the trains do not stop unless they are signalled by a flag or other signal to do so. They are simply wooden shelters from the weather, often having only three sides inclosed, the fourth being left open. Their cost should be about $100. A fixed signal is usually placed at a convenient distance from the station, so that it can be operated by the passenger wishing to board the train, providing there is no station agent at that point, in which case the brakemen of the train lower the sig-

nal again before the train moves off. A TURNTABLE is a revolving platform for turning locomotives around horizontally. Suppose, for example, a straight piece of track with the terminal ends A and B: the engine starts from A and pulls the train to B; now, in order to run the engine back to A, it must run backwards or else be turned around by some mechanical means; for this purpose a turntable is used. Turntables are made of wood or iron and in every variety of construction. A wooden one is not so expensive as iron, but is not so desirable to have. A good wrought-iron one of 50 feet diameter, to carry an engine and tender weighing 133,000 pounds, will cost from $900 to $1000; while one 45 feet in diameter will cost from $730 to $800 complete. WATER STATIONS are placed at certain points along the line of the road to supply the engines with water. They consist of small frame structures surmounted by a tank with a

of water by steam pumps, hand power, horse power, and in the West very often windmills are used for this purpose. The tanks are built circular in shape or often square, and are used as reservoirs for water, being always kept full. The water may be supplied from a neighboring spring, brook, river, or a well can be dug and the water drawn from that to fill the tank with. The cost of a circular tank capable of holding about 25,000 gallons of water will be about $300 put into position. Steam is generally used for roads doing a large business. A good steam pump with boiler attachments complete, ready for work, can be estimated at about $500. A cast-iron stand which is connected with pipes to the reservoir or tank is placed alongside the rails, and in such a manner that a canvas hose conveys the water from it into the tank of the locomotive; the flow of water

being regulated by
the fireman of the l
the fast trains on th
do not stop to tak
long tank placed be
is kept filled with
letting down a sc
tive, scoops up
train is in motion
for locomotives,
conflicting as to
kind over anoth
coal, and anthra
each is strongly
using that pa
Philadelphia a
passenger engin
cars consumes a
coal in 100 m
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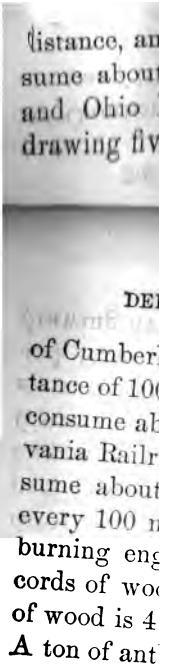

Properties of Fuel.

Kind of fuel.	Lbs. of water evaporated per pound.	Per cent. of carbon.	Cubic feet of air required for 1 lb. of coal.	Weight per cubic foot.	Cubic feet to stow a ton.
Bituminous coal	7 to 9	80	265	50	44
Anthracite	8 to 10	92	282	54	40
Coke.....	8 to 10	86	245	31	72
" Natural Virginia	8 to 9	80	260	48	48
" Cumberland	8 to 10	80	250	32	70
Charcoal.....	5 to 6	96	265	24	104
Dry wood	4 to 5	44	147	20	100
Wood, 20 p. ct. water	4	34	115	25	100
Turf, dry (peat)	6	51	165	28	80
Turf, 20 per ct. water	5	40	132	30	75
Illuminating gas.....	13.8	...	194	0.37	29,800
Oil, wax, tallow	14	71	200	59	37
Alcohol	9.56	58	154	52	42

Stationary engines use 3 to 7 pounds of coal per horse-power per hour.

Locomotive passenger engines 25 to 30 pounds coal per mile.

Locomotive freight engines, 45 to 55 pounds coal per mile.

Wood-burning locomotives, 1 cord of wood to 40 miles.

DEPOTS AND

Bulk of wood about 6 times as much as an equivalent of coal.

At certain points on a long road, or at the terminal station of a short road, a COALING PLATFORM must be erected in order to supply the engines with coal. These platforms are so arranged that coal can be conveniently hauled on to them and stored there; when an engine is to be supplied, the coal is dropped through shutes from the platform into the tender of the locomotive. The cost of these platforms will depend on their size.

ENGINE HOUSES are built of wood or brick, depending entirely upon the necessities of the road. A house built in the form of a segment of a circle is the most convenient form for a road operating a large number of locomotives. A turntable is generally placed at the entrance to an engine house both for convenience in "housing" the engine and to turn them around whenever required. A brick en-

gine house of this kind, designed for a number of engines, will cost about $1000 per engine stall,—a wooden house is only intended as a temporary covering, and is very seldom used.

ROAD CROSSINGS, or points along the line of the railroad where it crosses common wagon roads and streets, are, as a rule, grade crossings, that is, the street is on the same level as the railroad which crosses it. On some well regulated railroads, running through crowded cities and crossing streets at grade, gates made of iron are put up and so arranged that no wagons can cross the railroad until the train has passed. This arrangement is also used in England at every grade crossing, and every precaution is taken to avoid accidents to passing vehicles. There are many situations in which a bridge to pass a highway over a railway track would be very expensive, and this is a strong reason for having level crossings; and in some situations, near

stations, there would be inconvenience in the approaches to the railway. That highways should pass over or under a railway no one will doubt. Level crossings have caused much personal injury, the loss of many lives, persons maimed for life, and much damage to property. The locating engineer should consider well every facility for obviating the necessity of a level crossing, especially where there may be obstructions preventing a good range of sight. The subject is of sufficient importance to justify some modifications in the grade or alignment, if by that means a highway may be passed by a bridge. To raise an embankment to the elevation required to pass over the railroad sometimes interferes with other avenues or objects to such a degree that it cannot well be done; but if there be nothing of this kind, and the expense of raising the bank for landing the highway over the railway be the only objection, the case should be very unfavorable to

warrant a level crossing. The objection to merely an elevation of the highway, as injuring the public accommodation for travel, is by no means worthy of being placed against the benefits the travellers on the public road will derive from the safety from collision that will be secured by the bridge.[1] The same reasoning holds good as to farm crossings. Serious accidents have occurred on these when made over the level of the rail. A good timber farm bridge, crossing a single track road, can be built for about $500, and the damages arising from one collision would pay the entire cost.

[1] Jervis, "Railway Property."

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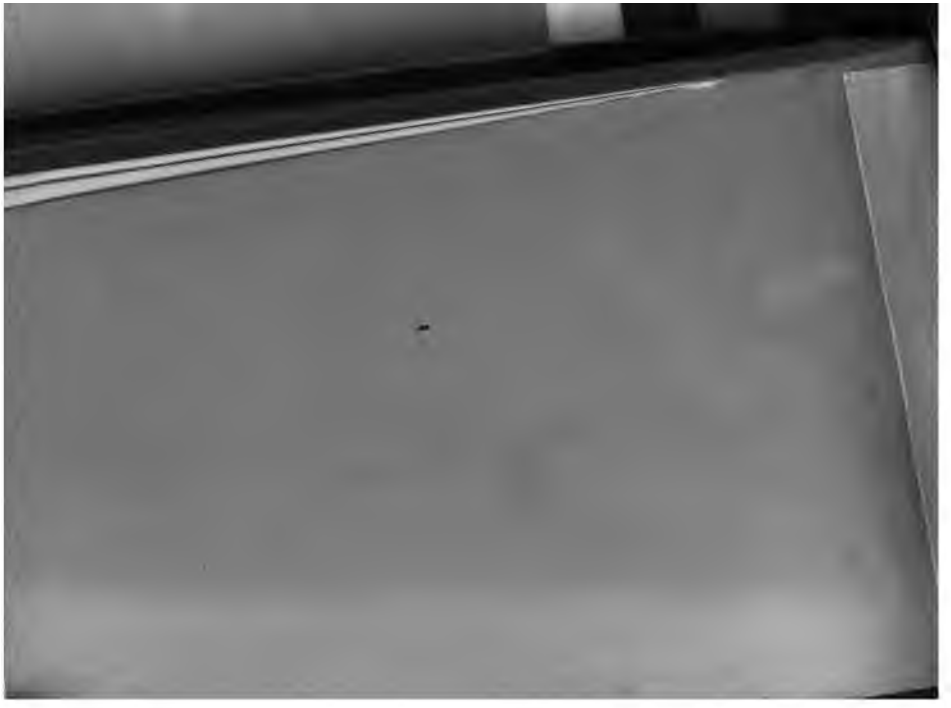

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